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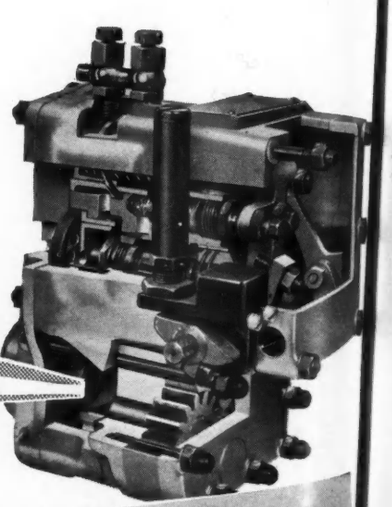

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BRITISH ELECTRICITY

THE annual report and statement of accounts of the British Electricity Authority for the year ended March 31, 1955, which were published this week, will be the last of the series to appear under that title. As is well known, on April 1 the Authority was deprived of the undertakings in South Scotland which it had previously directed, and was given a new title, the greater comprehensiveness of which might by some be deemed to be unjustified. This change should not, however, affect the activities of the new body to any great extent, except numerically; indeed, there is every prospect that its development will continue in the face of many difficult but interesting problems.

The Central Electricity Authority, to employ its new title, continues to be one of the few nationalised industries which financially is not "in the red." The Authority itself had a surplus of £11,576,054, compared with £8,011,727 in 1953–54, and the Area Boards added £7,218,424, compared with £5,177,011 in the same year. Individual results, however, varied considerably, although in only one Area—South Wales—was there a deficit. These results were obtained in spite of the fact that the average price received for electricity sold for all purposes was 1·37*d.* per kilowatt-hour, compared with 1·373*d.* in 1953–54.

There are, however, indications that this downward trend will be reversed in the near future. Stress is laid in the report on the continuing necessity of providing capital for development. Indeed, this is the dominant feature of the financial position. Some £203 million is likely to be required annually for this purpose, and an even greater sum may be needed as the construction of the more costly nuclear power stations proceeds.

The present large sum is to a considerable extent being provided by borrowing, but if the industry's financial stability is to be ensured it will, as is rightly pointed out, be necessary to earn larger annual surpluses in order to provide for a greater degree of self-financing of new work. As it has also been wisely decided to provide additional sums for depreciation, and the cost of coal has risen and is likely to continue to rise, it will be clear that to avoid increases in the prices of electricity to the consumer will be difficult. Nevertheless, it is a prime duty of the Authority to sell as cheaply as possible, and, as increasing consumption should assist towards this end, it is to be hoped that due restraint in this direction will be exercised. During the year the surplus was equivalent to 2¼ per cent. of the combined revenues and to only ½ per cent. of the value of the fixed assets—points which require no comment.

A satisfactory feature on the technical side of the Authority's activities is that the shortage of generating plant has been overcome. At the conclusion of the twelve months under review the total installed generating capacity was 20,173 MW, of which 1,539 MW was brought into service during the year. This was twice as much as the maximum in any pre-war year and over four times as much as the total for 1947—the pre-vesting year. This large accretion of modern plant has perhaps naturally been accompanied by a satisfactory increase in the overall thermal efficiency, the average figure for which during the year was 23·85 per cent., compared with 23·4 per cent. in 1953-54. This result was attained in spite of the large amount of uneconomic plant which is still in use, although 30 MW of equipment coming under this category was shut down during the year and it is hoped that a further 1,885 MW will be discarded in 1955-56.

In this connection it is interesting to note that a new thermodynamic cycle is under investigation. One of the principal features of this is a superheater designed to permit direct heat transfer from the burning fuel to the steam. A further point of importance was the establishment of an operational research section under the chief engineer, among the duties of which will undoubtedly be the investigation of the problems outlined by Mr. J. Eccles in the paper read before the recent British Electrical Power Convention.

Constructional work also continued on the grid system, the major developments put in hand during the year being 149 route miles of 275-kV lines and 303 miles of 132-kV lines with the necessary substations. The erection of the super grid, in fact, proceeded satisfactorily and some 41 miles was in operation at that voltage. The existing 132 kV system was also considerably reinforced to meet the growing load and to increase the reliability of the supply.

The activities of the Authority, of which we give a more detailed account on page 447 of this issue, may not inappropriately be summarised by recording that during the year under review over 73,950 million kilowatt-hours were generated and over 62,400 million kilowatt-hours sold, 11·9 per cent. more than in 1953-54. That the increase in consumption should continue at so high a rate is a striking illustration of the part electricity is playing in the industrial, commercial and domestic life of the country and the fact that no less than 14,796 farms were connected, bringing the total up to 167,375, all shows the extent to which electrification is penetrating into all activities.

Weekly Survey

Cover Picture: *When a blast furnace is tapped the molten iron may be cast into a hot-metal ladle for direct conveyance to the steel melting-shop mixer, or it may be cast into pigs on a sand bed adjoining the blast furnace. This week's picture shows the liquid iron flowing from the right-hand side of the illustration towards the left, on its way to the pig beds. The spade-like object is a "shut-plate" or "shutter" which, when thrust down into the sand, prevents further iron from entering a side runner or "sow" when its row of pigs is full.*

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INVESTMENT AND THE TRADE BALANCE

The Chancellor of the Exchequer is receiving a good deal of advice from industry, especially on the cut in expenditure which it is anticipated he is about to make. In particular, he is told to reduce the investment of the nationalised industries. This advice seems to be beside the point: what is needed is to ensure that the investment which takes place, whether in private or public industry, is going to contribute to higher productivity and assist the balance of payments. An examination of the latest trade figures shows that out of an increase of imports during the first eight months of this year of £350 million, increased imports of coal and of iron and steel accounted for over £78 million. This represented nearly 30 per cent. of the worsening of the trade balance for the period.

In spite of all the difficulties, an increase of coal output is still the best and most economical way of dealing with our increasing energy needs for many years to come. The Coal Board should by now be building up the staff of engineers, the lack of which has so far held back its development plans, and it would be short-sighted policy to restrict the Board's investment now.

A growing part of the steel imports has been of plates and sheets, due to the heavy demands of the motor and domestic appliance industries. So far, the re-imposition of hire purchase restrictions have had little effect and shortages are being felt in industry, including shipbuilding, in which the shortage of plate has been endemic since the war. The increasing use of fuel oil is also a contributory factor by increasing the demand for sheet for oil refining and storage plant. The iron and steel industry is now predominantly in private hands, but it is presumably sensitive to the views of the Government, which continues to exercise some control through the Iron and Steel Board.

In its first report, published this year, the Board described the industry's further expansion plans. Even if domestic demand is temporarily curtailed, the expansion of the engineering, chemical and oil industries will ensure a continual growth in the use of iron and steel products. Any slowing down of the steel industry's investment plans at this time might well have seriously damaging effects on the country's economy in a year or two's time.

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ARMY ON THE MARCH

The scope for improving the design of tanks and the efficiency of radio communication is evidently recognised by the Army as of vital importance. The development of rockets, nuclear weapons and military aircraft may seem to predominate in work on armaments, but the Army is feeling its way towards an organisation which will enable the movement of men on the ground to remain a vital factor in warfare.

Is it realistic to persist in a belief in the Army's traditional role? General Sir Richard Gale, who commands the Northern Group of the British Army in Germany, evidently thinks it is. Speaking on Exercise Full House in Germany last week he explained that in fighting a strategically defensive battle in nuclear war only certain areas, selected for their intrinsic value and geographical suitability, would be held. By making full use of natural features like hills to screen troops from the effects of enemy atomic air bursts, there should be a good chance, he believed, of holding these areas. Between the areas so held there would be large gaps, constituting formidable killing grounds for nuclear weapons against enemy concentrations. But to exploit the effects of nuclear weapons there must be highly mobile troops ready to strike.

In the experimental organisation for a light armoured division there is only one infantry battalion, transported in armoured carriers, for defence when the tanks laager and for minor operations. In the experimental infantry division, mortars and anti-tank guns are scrapped to increase the infantryman's mobility, but an armoured regiment in each brigade replaces the battalion anti-tank guns and enables the infantry to attack. Nuclear weapons would take the place of the Army Group Royal Artillary (Agra). The importance of communications behind the division—and within the division—is in proportion to the mobility of the Army. Mobility depends on communications, and both depend on equipment.

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TANKERS FOR THE OIL COMPANIES

Following in the wake of the recent announcement of the Peninsular and Oriental Steamship Company's decision to build a fleet of tankers (discussed in Weekly Survey last week), two large oil companies have now made known their intentions. It had been expected for some time that the large oil companies would soon announce new building programmes, and the formal announcement came at the end of last week when it was known that the Royal Dutch-Shell group and Esso Petroleum have started a new building programme which will cost altogether over £70 million.

The Shell group has placed orders for 34 ships, half of which will be 18,000-ton vessels and the other half 32,000-ton ships. Esso have ordered six ships of 36,000 tons each and it is understood that this includes the two 36,000-ton tankers recently ordered from Vickers-Armstrongs. Between them, therefore, the two companies have placed orders for 34 vessels amounting to a total deadweight of 1,066,000 tons. It seems likely that Shell will place further orders in due course. British yards are building 20 of the Shell tankers and the remaining 14 are to be built in Holland. Two of the Esso ships are being built in this country and the other four have gone to Germany, mainly, it is said, owing to the better delivery dates offered. Delivery of the Shell tankers is to begin in 1958 and to be completed by 1960, which means that there will be a steady flow of new tonnage into operation by Shell after the building programme which is now well in hand and due for completion in 1957 has come to an end. The British company is to deliver the two Esso ships in 1958 and the four German tankers are to be ready in 1957 and 1958.

Other oil groups have still to make known their plans and it will not be until these, notably the British Petroleum Company's, are known that a full assessment of the impact of the new tanker programme on world tonnage can be thoroughly assessed.

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UTILISATION OF ELECTRICITY

What might be described as a survey of the industrial and domestic markets for electricity in Western Europe has been carried out during the past three years by the Study Committee for the Optimum Utilisation of Electrical Energy, under the aegis of the International Union of Producers and Distributors of Electrical Energy. The committee, who first met in September, 1952, presented a number of reports covering various aspects of their study to the London Unipede Congress last week.

A short report by the chairman of the International Interconnections Study Committee presents an account of the exchanges of electrical energy carried out between the interconnected European countries. These exchanges, though small in volume, are considered very important, particularly for countries mainly dependent on water supplies for electricity generation. One example quoted is Switzerland in the winter of 1953–54, when the low level of water in the country's reservoirs would have made it impossible to generate sufficient electricity to maintain the supply during the most heavily loaded months. Shortly after the committee began its work, the Union pour la Co-ordination de la Production et du Transport de l'Electricité was formed and substantial achievements have been recorded. The ratio between the energy imported into the seven members of U.C.P.T.E. (Western Germany, Austria, Belgium, France, Italy, Holland and Switzerland) and the energy produced in the same countries (100 × energy exported ÷ energy produced) rose from 2·18 in 1949 to 3·16 in 1954. In the committee's own words: "Interconnection can represent the most efficient, the quickest and certainly the most economic means of avoiding power or energy crises following on unforeseeable incidents, a poor water position, a delay in commissioning new plant, or an increase in load exceeding the forecasts."

The development of trade in electrical energy may in time replace some of the trade in solid fuels, and the progress of U.C.P.T.E. will be watched with interest in this country, where considerable benefits might be derived from interconnection with continental Europe.

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DOMESTIC APPLICATIONS OF ELECTRICITY

The general report on the development of domestic applications of electricity, which is based on a three-year study, contains a great deal of interesting information about the degree of electrification in eleven European countries, including Britain. It is in two main sections: the first reviews the development of consumption over the last few years, its distribution among the principal applications and the extent to which the latter are found among consumers. We learn, for example, that domestic consumption in 1953 in France was 8·9 per cent. greater than in 1938, whereas in Portugal and Switzerland it was 14 per cent. greater, in Italy 13 per cent. and in Britain only 4·8 per cent. The figure for average consumption per consumer was highest in Switzerland, followed by Britain and Sweden; other countries were left far behind and none reached one-third of consumption in this country. Switzerland and Britain were also well ahead in the amounts consumed for cooking, water heating, refrigeration and in washing machines. One part of the first section of the report is devoted to a study of the different countries concerned, another to a study of regions belonging to different countries but having comparable geographical and economic features.

The second section of the report is devoted to the trend of the "relative cost" of electricity for domestic applications, compared with the trend of local purchasing power and the cost of living in different countries. This relative cost has been considerably reduced since the pre-war years but the authors point out that the influence of the cost factor on the development of consumption should not be overestimated "in view of the small part played by the electricity bill in the family budget."

The study, and another on the organisation and operation of the domestic electric appliance market, are too detailed in character to allow much general comment—perhaps an inevitable consequence of studies involving a number of widely different countries. They are, however, of value to the electricity producer and the manufacturer of domestic electrical appliances seeking to expand sales and to make forward estimates

of demand. In this respect the reports are well worth a detailed study.

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EXPORTING MANPOWER

Italy has won a large steel-mill contract from the Government of Venezuela against six competitors. Preliminary estimates were submitted by groups of companies from the United Kingdom, the United States, Germany, Belgium, France, and Norway but the contract, estimated to be worth between 50 million and 100 million dols., depending on the final size of the plant, has been gained by the Fiat Motor Company of Turin. A good deal of the work and equipment will be sub-contracted by Fiat, and British companies may get some of these orders, but it is natural that the lion's share of the work will be done by Italians.

It is thought that the Italian prices in the tender were considerably lower than those submitted by other groups of companies, some of whose members have been engaged in the erection of steel mills for a very long time. Of even greater interest, however, is the report from Germany that the transfer of Italian labour to Venezuela is involved in the contract. Venezuelan engineers are already undergoing training in Italy at the Genoa Steel Institute with a view to assisting with the job, and there is nothing out of the ordinary in special arrangements for the training of technicians. If, however, as seems very probable, the contract is being made the means of supplying Venezuela with cheap semi-skilled and unskilled labour from an Italy which has a critical manpower surplus, an entirely new and significant issue has been brought into the international engineering market. Not only could the transfer of workers from Italy to Venezuela provide a useful contribution towards the employment problems of these countries, but the fact that Italian labour is being moved could well mean that cheap, hard-working unskilled manpower is being used on this steel mill and that the benefits in cost have been written into the contract. This is the kind of arrangement which could give Italy a useful advantage in the world capital goods market. No one has ever doubted the skill of Italian engineers. If they can export that skill along with cheap labour to the so-called underdeveloped territories of the world which are now fostering their capital goods industries, that country has an impressive formula for competing against companies in the United Kingdom, the United States and Germany.

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B.T.H. AT LARNE

When the Prime Minister of Northern Ireland laid the foundation stone for the office block of the new B.T.H. turbine works at Larne this week, the seal was set on what must have been a series of intricate and difficult decisions for the British Thomson-Houston Company, Limited. Larne is exceedingly fortunate to get this new factory, which altogether will have cost £8 million when it comes into operation in 1957, and which will be the largest steam-turbine works in Europe. Over 3,000 people, from professional engineers and executives to unskilled workers, will be employed in the new works which is being built on a 70 acre site. The town has extensively replanned the locality to accommodate up to 2,000 new houses.

It was intended originally to instal only a blading factory at Larne but the heavy demand for B.T.H. turbines was beyond the capacity of the Rugby works and a new site had to be found. It was decided to put this down beside the blading works. The decision must have been difficult for the company, since the site chosen is not in a locality with a surplus of skilled manpower. In consequence, the company started a large training scheme in 1953, when 10,000 sq. ft. were rented in Larne and equipped for blade manufacture. By February, 1955, 100 operatives were transferred to the blading factory and commercial production of blades began after what had been two years of pilot work occupied in training unskilled labour. Now the blading factory is to be used as a pilot factory for the main works and a second training scheme is in operation.

One of the problems in deciding to spend £8 million at Larne must have been transport. The company hope to keep raw-material transport charges down by ensuring that vehicles used for raw materials over the Preston to Larne ferry obtain two-way loads, and by buying raw materials for the new factory mainly ex-works, taking supplies in their own transport. Special berthing of ships in Belfast Harbour will be organised to get the maximum advantage from the short land haul. It is expected that the consequential higher shipping costs will be offset by the improved manufacturing methods at the works, which should reduce costs overall. The entire project will be followed with interest as an outstanding example of engineering techniques, economics and administration.

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CAR COSTS AND PRICES

The announcements last week by Rootes and Rover of price increases for their new cars—ranging from £17 to £150 and from £28 to £42 respectively—came as no surprise. Substantial cost increases have taken place during the past few months and others are likely to follow, despite the increase in the industry's output so far this year. Output during the first seven months averaged 73,500 compared with 63,200 for the same period a year ago, or an increase of over 16 per cent. Whether or not other manufacturers will follow Rootes' lead is not certain, but so far none of the other " Big Five " manufacturers has said definitely that they would not increase their prices. Ford and Vauxhall said they would announce their prices and programmes shortly before the Motor Show opens next month and the British Motor Corporation say that they have no immediate intention of announcing any price increases for current models. Of the specialist manufacturers only Armstrong Siddeley and Jaguar have definitely stated their prices would remain unchanged.

There is little doubt that the increases in costs have been experienced by everyone in the industry, and some of the component manufacturers have already increased their prices—among them makers of castings, forgings and body builders. The larger car manufacturers may not, however, be prepared to announce price increases at a time when exports are due to decline seasonally, since a fall in output could cost far more than to absorb rising production costs and leave selling prices unchanged. There is also the consideration of competition from German, French and other foreign manufacturers. At the opening of the Frankfurt International Motor Car Show a week yesterday, the two main features were stable prices and many technical improvements. Confident statements were made by Herr Koenecke, chairman of Daimler-Benz, and Herr Nordhoff, chairman of Volkswagen, whose outputs—and exports— have been rising rapidly. Herr Koenecke warned the German industry, however, that it might well be over-expanding and suggested that some of the companies would be well advised to review their investment programmes.

The large companies, in this country as well as in Germany, are striving hard to increase their lead. Despite the strength of demand, therefore, it is possible that prices will be held down, though it is probably too early to speak of a major price war—at any rate so long as delivery dates of popular models are as protracted as at present.

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ROAD OF THE FUTURE?

Firm proposals for the first section of the London-Yorkshire motorway were announced by the Minister of Transport on Tuesday, September 20. The stretch of road to be built is 53 miles long and runs from the north end of the St. Albans By-pass, south of Luton, to Watford Gap, near Ashby St. Ledgers, Northampton; from Watford Gap a spur connection to Dunchurch on to the A45—the London-Holyhead trunk road—will provide a link for Birmingham traffic.

A survey of the need for and requirements of motorways was given by Mr. J. A. Proudlove in a paper presented to this year's British Association meeting and published in our last week's issue. The proposed section, expected to cost £15 million, is to have two carriageways each 36 ft. wide separated by a central reservation and flanked by hardened verges for use of traffic in emergencies. Beyond Watford Gap, the spur to Dunchurch will have two 24 ft. carriageways. The motorway will be for the exclusive use of selected motor traffic and no frontage access will be permitted. The new road will be carried over or under all existing roads, and at six important junctions there will be flyovers with underpasses to keep the traffic flowing smoothly.

The present position is that the plans have been published as required by the Special Roads Act, 1949, and are available for inspection by interested parties, and for three months, from September 24 until December 24, any person may make representations to the Minister or lodge objections. The Minister has also to publish a draft Order showing the proposals for alterations to side roads and to public and private rights of way affected by the proposed alignment. There are no technical reasons why a road of superior quality should not be built—and built quickly—and £15 million is not such a large sum that financial issues should delay construction. It remains to be seen how quickly the Minister, with the support of informed public opinion, can eliminate objections.

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RAILWAY DELAYS

When General Sir Brian Robertson, chairman of the British Transport Commission, opened the new apprentices' school at Crewe last Friday, he gave an instance of the delays which hamper the railways in their efforts to modernise. Approval for building the school was given, he said, in July, 1951. The foundation stone was not laid until more than two years later—by Mr. R. A. Riddles on September 22, 1953. Then it was two years and a day before the school was formally opened. More than four years for a job which should have been done in less than a year.

This delay must have had an adverse effect on the recruitment of apprentices. To-day the railways cannot rely, as they did in the past, on an ample supply of boys wishing to enter the service. For various reasons they have to meet strong competition from other industries. Another difficulty is likely to arise in the future: unless British Railways are permitted to spend more money on their workshops and other installations they will find it increasingly difficult to retain the craftsmen they have trained. Full use must be made of modern scientific and engineering equipment if men trained in a modern school are to be attracted by the prospect of continued railway service. It is true that the railway workshops are capable of fine precision work, as Mr. K. J. Cook (chief mechanical and electrical engineer of the Eastern and North Eastern Regions) said in his presidential address to the Institution of Locomotive Engineers last week, but the overall condition of railway plant and equipment is low. Essential components of the £1,200 million modernisation plan must be the improvement of plant and, at the same time, arrangements for attracting more professional engineers and for allowing those already in the railways to acquire new knowledge. The Commission have announced details of a plan for a new testing installation for studying the behaviour of vehicles on the tracks. It will be interesting to see how quickly they are permitted to carry out this work. Two years is the Commission's present estimate.

APPRENTICE SCHOOL AT CREWE LOCOMOTIVE WORKS

Practical and Theoretical Instruction

The shortage of trade apprentices for the Crewe locomotive works of British Railways has been one of the main reasons for building the training school which was opened on September 23 by General Sir Brian Robertson, chairman of the British Transport Commission. With a total of 7,000 personnel in the works it is necessary to recruit about 200 boys a year. These boys, together with about 100 from other railway departments (motive power, civil engineer's, signal engineer's and road motor), will spend their first year at the school and then go into one or other of the shops to complete their apprenticeship at the age of 21.

Until the Rolls-Royce factory was started at Crewe just before the last war, the L.M.S. Railway, and before it the L.N.W. Railway, had a virtual monopoly in the local recruitment of skilled labour. The new school, described as " the most ambitious of its kind undertaken by British Railways," will attract, it is hoped, sufficient boys to meet future requirements of turners, fitters, smiths, welders, pattern-makers, moulders, core-makers, die-sinkers, coppersmiths, sheet-metal workers, platers, instrument-makers, riveters, plumbers, joiners, painters, electricians, bricklayers and brass-finishers (i.e., fitters working on boiler-mountings, etc.).

About two-thirds of the time will be spent on practical work and the remainder on class study. The classes are regarded as complementary to the Crewe Technical College's National Certificate and City and Guilds courses. The subjects in the curriculum are, in order of most hours spent: workshop mathematics, workshop science, workshop theory, freehand sketching and machine drawing, individual expression, industrial history, industrial geography, and first aid.

The main workshop, illustrated below, is divided into sections for turning, fitting, etc., and includes a model-making section. There are also a smithy and moulding shop, welding shops, stores, etc., as well as showers, a gymnasium (which can be used as an assembly hall and cinema), lecture rooms and a library.

The conception and development of the school were the work of Mr. E. J. Larkin, assistant mechanical and electrical engineer of the London Midland Region. Design and erection (on the site of the disused carriage works) have been carried out under the direction of Mr. J. Taylor Thompson, chief civil engineer of the Region. The general contractors were Holland & Hannen and Cubitts, Limited. At the opening ceremony Mr. J. W. Watkins, general manager of the Region, took the chair, and Mr. J. F. Harrison, chief mechanical and electrical engineer, proposed a vote of thanks.

(*Editorial comment in Weekly Survey*)

EVANGELISTS IN INDUSTRY

THE WORK OF THE EUROPEAN PRODUCTIVITY AGENCY

With crusading zeal the American officials who poured into Europe to administer the Marshall Plan have preached the doctrine of higher productivity. Originally regarded by General Marshall and Ernest Bevin as a means of temporarily bridging the dollar gap by a peacetime form of Lend-Lease, it was sold to the United States Congress as a programme to make the European nations economically strong and independent by increasing their industrial efficiency and liberalising their trade. Now that the programme is ended, it can be seen to have been brilliantly successful in its main task. Although it has not led to the European common market for which so many Americans hoped, except to a limited extent for coal, iron and steel, it has left behind in the Organisation for European Economic Co-operation perhaps the most successful of the post-war international bodies.

Almost as a legacy to O.E.E.C. were the funds by means of which, two years ago, the European Productivity Agency was founded. The foundation fund was provided by what is now called the Internation Co-operation Administration of the United States, and the current budget is provided by the 17 member countries, chiefly out of counterpart funds in their own currencies of the dollar aid which they have received.

The Agency has for its objects the formation of a European centre for planning and research on productivity problems and, by working through the responsible national bodies, the stimulation of greater productivity in industry and agriculture. In some countries the responsible body is an autonomous or semi-autonomous organisation, and in others a branch of the central government. In the United Kingdom the overall administrative responsibility is that of the Board of Trade, while the Department of Scientific and Industrial Research is responsible for the technical and information aspects of the agency's work. In this the Department works in co-operation with the British Productivity Council.

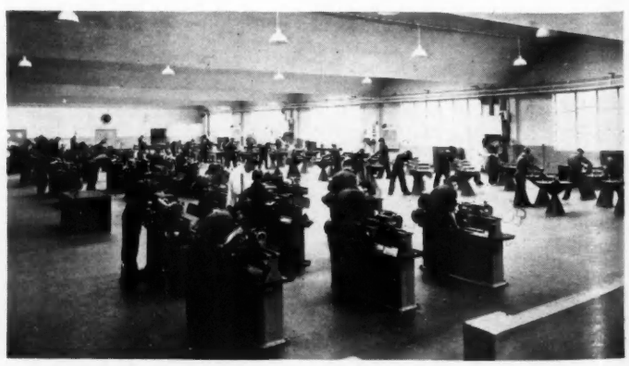
ATTITUDE OF STEEL WORKERS

No general project is started by the Agency unless it has the support of at least five member countries, and the Agency does not itself undertake research. It arranges for work to be done in universities or research institutes, and an interesting experiment is the conduct of a similar piece of research, with full exchange of ideas and methods, in a number of countries simultaneously. An example of this is a study of the attitude of employees in the steel industry to technological change. As a result of a conference held in Paris last June, an international symposium on the progress of automation and its social and economic concomitants is to take place, when reports from eight European countries will be discussed. One of the most important conferences held this year was on statistical quality control, at which a number of extremely interesting papers were read. This has led to the setting up of an international quality-control institute. A European congress on productivity in the textile industry was held in Ostend in July, attended by delegates from 12 countries as well as the International Labour Organisation and the International Federation of Textile Workers' Associations. The conference is reported as recognising that the formation of a European market would increase productivity in the textile industry; but this it did, presumably, with its tongue in its cheek. Perhaps the most valuable work in the research field which the Agency is encouraging is in the comparative measurement of productivity, which owes its inspiration to the enthusiastic work of the team of specialists on productivity measurement which the U.S. Bureau of Labour Statistics has maintained in Europe for some years. A productivity measurement advisory service has been established and a *Productivity Measurement Review* is being published. It is hoped shortly to be able to publish a table assessing the productivity of a number of European countries and the United States, and comparing the increases that have taken place in recent years.

The Agency does not itself sponsor research in technological subjects, but confines itself to assisting in the creation of a climate in which the results of research will be promptly applied in industry. It encourages visits of teams between different countries, and a number of trade-union missions of this type have taken place. In August, an international seminar for trade-union leaders was held near Paris. The first trade-union official to join the staff of E.P.A. was Mr. Edwin Fletcher, head of the T.U.C. Production Department, who was appointed Deputy-Director in July this year.

SMALLER FIRMS

As with so many similar bodies, there is a kind of hectic evangelism about much of the writing in the Agency's publications and one cannot avoid wondering who it is that reads this great quantity of printed matter, so full of good intentions, clichés and references to organisations described only by unrecognisable initials. Unfortunately, there is no way of measuring the effects either of the work as a whole or of specific aspects of it. There is no doubt that an educational job still needs to be done in many parts of British industry as much as anywhere, and the educational and information services provided are, therefore, probably the most immediately useful. Recognising the need to reach the smaller firms, a meeting was held last year to exchange ideas on methods of getting information down from the national bodies to the individual firm. A series of technical digests, suitable for small firms and containing information from over 1,000 periodicals, is being published



In future, all trade apprentices in Crewe locomotive works will spend their first year in the new training school opened by General Sir Brian Robertson last week. The school is described in an article above, and is shown here with a view of the main workshop.

in English and French and is translated into their own languages by a number of other countries. In the United Kingdom, appropriate items from these digests are distributed to industrial research associations and are available through the D.S.I.R. Information Service. An "International Guide to Sources of Technical Information" is being compiled for the use of technical information centres and similar organisations. It is being confined to primary sources of information in the fields of pure and applied science and technology, except agriculture and medicine, and will list the national guides used as its basis and provide a guide to sources of information about consultants in various fields.

The Agency has started a big programme of visual aids for training purposes; the Ministry of Works has asked it to produce a series of films on building techniques and seven films on work study are being produced by the British Productivity Council, which is paying half the cost.

The value of such an organisation as E.P.A. must in practice depend on the use made of it by industry in the member countries. Obviously, some of the less industrially advanced countries will get more benefit than those whose research and information services are well developed. Perhaps in the end it will be judged as one more of those useful, if undramatic, functional international organisations which seem likely to have a more permanent effect on European unity than the more ambitious schemes advocated by some political enthusiasts.

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Letters to the Editor

THICK-WALLED CYLINDERS UNDER INTERNAL PRESSURE

SIR, We were very interested to read the letter by Mr. S. M. Jorgensen in your journal of September 16 commenting on our article on "The Ultimate Strength of Thick-Walled Cylinders Subjected to Internal Pressure" (ENGINEERING, vol. 179, pages 80 and 114).

The last two equations for ultimate pressure are an improvement on that suggested by Professor van Iterson, as the value of K at the ultimate pressure is used, and an approximate allowance is made for the actual stress distribution. In the authors' opinion, however, there is no true theoretical foundation for either of these equations.

We cannot completely understand the third paragraph of Mr. Jorgensen's letter, but we do not agree with the equation

$$\epsilon r^2 = \text{constant} \quad . \quad . \quad (1)$$

Equation (1) is only true for small strains, at large strains the equation should be

$$2r^2\epsilon + \epsilon^2 r^2 = \text{constant} \quad . \quad (2)$$

which reduces to (1) for small strains. As the strains at the ultimate pressure are large, equation (2) must be used.

Assuming equation (1) is correct we can deduce the equation

$$K' = \frac{K^2 + \epsilon_u}{K(1 + \epsilon_u)} \quad . \quad . \quad (3)$$

if we take $\frac{\epsilon_o}{\epsilon_u} = \frac{1}{K^2}$, but this conflicts with the last equation given by Mr. Jorgensen which gave

$$\frac{\epsilon_o}{\epsilon_u} = \frac{1}{(K')^2}$$

We should like to see a comparison between experimental results and those predicted from the equations suggested. Unfortunately, we cannot locate sufficient material from the bar used in our test to carry out tension tests to obtain the information required. At the present we are carrying out a further programme of tests on thick cylinders of another material, and we shall obtain comprehensive results in tension which will enable us to check the approach suggested by Mr. Jorgensen.

Though we can understand the desire to obtain the explicit equation for the ultimate pressure in terms of information obtained from tensile tests, we are convinced that this can never be entirely satisfactory.

Yours faithfully,

J. A. BONES.
B. CROSSLAND.

September 20, 1955.

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TECHNICAL EDUCATION
Work of the London Colleges

SIR, May I thank you for publishing your article "Technical Education" which appeared on page 365 of your issue of September 16. This article rightly stresses the work done at non-graduate level in technical colleges. However, it appears to do less than justice to the London polytechnics.

At least six polytechnics or technical colleges in the Greater London Area prepare students for the General Internal Examinations of London University in Science or Engineering. At least eight others provide courses leading to National or Higher National Certificates as well as the City and Guilds examinations. Much of this work is technological and contributes to the supply of trained engineers.

To take alone your example of the Northampton Polytechnic, courses are provided in civil, mechanical, electrical and aeronautical engineering for internal degrees of London University. Higher National Certificates are obtainable in these subjects, together with instrument engineering, production engineering, applied physics and applied chemistry. Provision is made for full-time, part-time day, evening and "sandwich" study in some or all of these courses, Students at post-graduate standard may also participate in research and attend special courses of lectures in modern technical developments. Work of similar standard is also done in other London colleges.

I think that it may be said, despite the need for further expansion of facilities, that the technical colleges do valuable work in supplying a substantial proportion of engineers.

Yours faithfully,

JOHN B. THIRLWELL.

20, Crediton Hill,
London, N.W.6.
September 20, 1955.

SIR, I would like to congratulate you on the comprehensive and interesting way in which the industrial side of the work of technical colleges throughout the country has been summarised in such a short space.

At the end of enrolment week at this College one quite marked trend has been noticed, namely the continued swing from evening to part-time attendance on the part of industrial apprentices. There is an increasing number of firms which continues the day-release privilege above the age of 18 years; the model apprenticeship schemes of the Central Youth Executive are generally being adopted; and deferment until the end of apprenticeship is more frequent. All these factors contribute to promote increased day attendance. This in turn makes for more satisfactory teaching, less wastage of students and a better balance in the work of the College.

I thought it might be of interest to your industrial readers to say this, and, as it were, to thank them for their voluntary implementation of a certain section of the Education Act, 1944.

Yours truly,

HUGH A. WARREN,
Principal.

South East London Technical College.
September 23, 1955.

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ISOTOPE RADIOGRAPHY EXPOSURE TIMES

SIR, In the issue of ENGINEERING dated September 16 there appears on page 398 a review of equipment for radiography using radioactive isotopes. While in no way wishing to comment on the apparatus which is no doubt correctly described, I would question those remarks made concerning exposure times.

It is stated that, using 20 curies of cobalt or 2,000 curies of caesium, exposures for steel sections 12 in. thick are only a "few moments." This statement is, Sir, surely incorrect.

Consider first the 20 curie cobalt source and let the film be placed as close as possible to this source only leaving space for the specimen to be interposed, thus giving a source to film distance of 12 in. or say 25 cm. At this distance in the absence of the specimen the film will be subjected to an X-ray dose rate of approximately 400 roentgen per hour (cobalt provides 1·3 roentgen per hour per curie at 1 m.). As a rough value we may assure that 1 roentgen exposure is required to affect the film and we thus see that an exposure of 9 seconds would be required if the steel were completely transparent. In fact steel is far from transparent and attenuates the radiation very appreciably. Published figures of the absorption of cobalt radiation in steel show some variation, and those for the Half Value Layer (the thickness required to reduce intensity by a factor of 2) range from 0·63 in. to 0·75 in. Taking a value of 0·72 in. it follows that 12 in. of steel will reduce intensity by a factor, in round numbers, of 100,000. Obviously the exposure of 9 seconds will be increased by this factor to allow for the absorption in the steel and we arrive at an exposure time of 250 hours. In practice so short a source to film distance would not be used as the distortion produced in the radiograph of a thick object would be intolerable, and it is unlikely that a distance of less than 1 m. would be found satisfactory for specimens of 12 in. thickness. Working at this increased distance would of course increase the exposure time and a value of 4,000 hours or approximately 6 months might be expected.

Turning to the 2,000 curie caesium source conditions would seem to be even worse since, although the quantity of X-rays emitted is greater (by a factor of 23), their energy is lower and therefore they are less penetrating. Calculations using an estimated Half Value Layer of 0·5 in. show that exposures for the 12 in. specimen would be about four times as long as those quoted for the 20 curie cobalt source.

In contrast with the above remarks it should be noted that in the writer's article on Linear Acceleration appearing in the same issue of ENGINEERING, it is stated (on page 376) that using a 4 MeV linear accelerator, steel objects 13 in. thick can be dealt with in a 1 hour exposure. Since the Half Value Layer for this equipment is 1·0 in. of steel, a 12 in. thick specimen would require an exposure of half an hour. It can thus be seen that the claim that isotopes can compete with modern high-voltage equipment as regards exposure time cannot be sustained—hundreds or even thousands of hours cannot be dismissed as a "few moments."

Within certain limits, say for steel up to 6 in. thick, isotopes provide a convenient method of radiography, but it should be noted that increasing the power of the source is not a practical solution to the problem of increased thickness of specimen. The answer to this problem is found in using radiation of greater penetrating power, that is, of higher energy, and X-ray equipment is available for this service. There are of course other factors to be considered in deciding an optimum equipment for the radiography of thick specimens and an account of such considerations has recently been given elsewhere by the writer.*

C. W. MILLER,
Research Department,
Radiation Laboratory.

Metropolitan-Vickers Electrical Co., Ltd.,
Trafford Park,
Manchester.
September 23, 1955.

* "Industrial Radiography and the Linear Accelerator", *Brit. Inst. Radio Engineers Journal*, vol. 14, No. 8, p. 233, 1954.

PERSONAL

SIR WILLIAM HALCROW, M.I.C.E., is to retire from partnership in Sir William Halcrow and Partners, chartered civil engineers, Alliance House, Caxton-street, London, S.W.1, as from October 1. He will continue to be associated with the firm as a consultant.

MR. W. KENNETH G. ALLEN has been elected chairman of W. H. Allen Sons & Co. Ltd., Queen's Engineering Works, Bedford, in succession to his uncle, the late SIR RICHARD W. ALLEN, C.B.E., D.L. He is the third member of the Allen family to become chairman of the company since it was founded by his grandfather, Mr. W. H. Allen, in 1880.

THE EARL OF DUDLEY, M.C., has retired from the chairmanship of Horseley Bridge and Thomas Piggott Ltd., Horseley Works, Tipton, Staffordshire, but is to continue to be a member of the board of directors.

London Transport Executive, 55, Broadway, S.W.1, have appointed MR. A. H. GRAINGER to the post of deputy chairman from October 1, consequent upon the retirement of MR. JOHN CLIFF on that date.

SIR JOHN WRIGHTSON, Bt., and MR. PETER WRIGHTSON have been appointed managing directors of Head, Wrightson & Co. Ltd., Thornaby-on-Tees. MR. RICHARD MILES is chairman and managing director and SIR JOHN WRIGHTSON, vice chairman.

SIR GEORGE BRIGGS has resigned from the board of Tube Investments Ltd., The Adelphi, London, W.C.2, on account of increasing commitments in industry, and has relinquished his appointments with the subsidiary companies of the Group. Sir George, however, will still be available to Tube Investments Ltd. in a consultative capacity.

DR. EZER GRIFFITHS, O.B.E., F.R.S., has been re-elected President of the Conférence Générale of the Institut International du Froid, 177 Boulevard Malesherbes, Paris, 7e., for a further period of four years.

SIR ERIC BOURNE BENTINCK SPEED, K.C.B., K.B.E., M.C., has been appointed to the British board of Engelhard Industries Ltd., 52 High Holborn, London, W.C.1.

MR. A. A. FULTON, F.R.S.E., B.Sc., M.I.C.E., M.I.Mech.E., has been appointed general manager, North of Scotland Hydro-Electric Board, in succession to the late MR. THOMAS LAWRIE. Mr. Fulton has been the Board's chief hydraulic and civil engineer since 1944.

In December, MR. V. A. PASK, C.B.E., M.I.Mech.E., M.I.E.E., chief engineer of the Central Electricity Authority, retires after 45 years of service in the electricity-supply industry.

MR. F. J. CRABB, B.Eng., M.I.C.E., is relinquishing his post as principal scientific officer in the Department of Scientific and Industrial Research (Building Research Station) to-day, September 30, and is taking up an appointment with the British Standards Institution, 2 Park-street, London, W.1.

The Ministry of Supply announce that DR. W. B. LITTLER, M.Sc., has been promoted chief scientific officer and appointed principal director of scientific research (defence) in succession to DR. W. CAWOOD, C.B.E., B.Sc., who is to become principal director of scientific research (air) on November 1.

DR. W. STEVEN, B.Sc., A.R.T.C., F.I.M., has been appointed superintendent of the development and research department laboratory of the Mond Nickel Co. Ltd., Birmingham, in succession to the late MR. HOWARD EVANS.

MR. ORLANDO OLDHAM and MR. P. J. BROCKLEHURST have been appointed to the board of directors of Oldham and Son Ltd., battery and mine lighting equipment manufacturers, Denton, Manchester.

MR. JOHN TAYSOM has been appointed works director of Cimex-Fraser Tuson Ltd., Orpington, Kent.

MR. A. E. UNDERWOOD has been appointed to the main board of the Plessey Co., Ltd., Ilford, Essex. He joined the firm in 1948, was appointed an executive director in 1951 and a director of Plessey International Ltd. in January, 1954.

MR. P. G. WARE, A.R.Ae.S., M.S.A.E., has been appointed chief engineer (electrical) to C.A.V. Ltd., Acton, London, W.3.

MR. K. W. WATKINS has been appointed project engineer to the Hymatic Engineering Co. Ltd., Redditch, Worcestershire.

MR. A. H. ELLIOTT has been appointed executive vice-president and general manager of Iricon Agency Ltd., London, which is acting as agent for nine independent American oil companies in certain matters relating to the Iranian Oil Consortium.

The Brush Group Ltd. announce that MR. J. P. FORD is relinquishing his post of managing director of their export companies (Associated British Oil Engines Ltd., Brush Exports Ltd., and National Oil Engines Ltd.), with effect from November 1, in order to join the board of Charles Colston Ltd. MR. M. C. CLEAR will assume the office of managing director of the three export companies from the above date in addition to his present office of sales director of the Brush Group Ltd. MR. G. N. BRIDGE is appointed London manager of the same companies with effect from November 1.

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COMMERCIAL

An agreement is announced between SIR GEORGE GODFREY & PARTNERS LTD., Hampton-road West, Hanworth, Middlesex, and the STRATOS DIVISION of the FAIRCHILD ENGINE AND AIRPLANE CORPORATION; both companies are designers and manufacturers of aircraft pressurising and air-conditioning equipment. The agreement provides for the exchange of ideas and techniques as well as making available to British and American aviation the products of both organisations.

DANIEL ADAMSON & CO., LTD., Dukinfield, Cheshire, have been manufacturing steam-raising plant since 1842. THE SOCIÉTÉ ANONYME JOHN COCKERILL, now COCKERILL-OUGRÉE, has been established in Belgium from original British sources for a similar period. Daniel Adamson have informed us that the technical resources and experience of the Cockerill-Ougrée organisation are now available to them for the design and construction of ADAMSON-COCKERILL water-tube boilers up to operating conditions of 1,100 lb. per sq. in. and 950 deg. F.

Through the co-operation of the Birmingham Chamber of Commerce, the BRITISH STANDARDS INSTITUTION has now opened a sales office in the headquarters of the Chamber at 95 New-street, Birmingham 2.

On October 1 the name of the INDIA RUBBER, GUTTA PERCHA AND TELEGRAPH WORKS CO., LTD., will be changed to the SILVERTOWN RUBBER CO. Ltd., Herga House, Vincent-square, London, S.W.1.

THE SOLARTRON ELECTRONIC GROUP, LTD., Thames Ditton, Surrey, have formed an INDUSTRIAL CONTROLS DIVISION under MR. WALTER TITMUS, A.Brit.I.R.E.

THE INSTITUTION OF MINING ENGINEERS have removed their offices from Salisbury House, Finsbury-circus, London, E.C.2, to 3 Grosvenor-crescent, London, S.W.1 (Telephone: BELgravia 3691).

THE INSTITUTION OF MINING AND METALLURGY left their offices in Salisbury House, London, E.C.2, some time ago and are now at 44 Portland-place, London, W.1 (Telephone: LANgham 3802).

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CONTRACTS

Pass-out Turbine. An order has been placed by the Donside Paper Co. Ltd., Aberdeen, with the GENERAL ELECTRIC CO. LTD., Magnet House, Kingsway, London, W.C.2, for a 3,000 kW pass-out turbo-alternator set. The direct-coupled machine, running at 3,000 r.p.m., will be provided with a surface-condensing plant manufactured by HICK, HARGREAVES & CO. LTD. The closed ventilated alternator will generate current at 3,300 volts and is designed for operation with a power factor of 0·8. The consulting engineers are J. D. CROZIER & PARTNERS LTD., London and Edinburgh.

Sterling Sub-Machine Gun. The first production orders for the Sterling sub-machine gun, the official nomenclature of which is the L.2A. series, have now been placed by the Ministry of Supply. It may be recalled that we gave an illustrated description of the gun on page 249 of our issue of February 25, 1955. The weapons will be produced at a Royal Ordnance Factory and at the Dagenham Plant of STERLING ENGINEERING CO. LTD., the designers and manufacturers. The Sterling gun will supplement the Belgian F.N. rifle as a standard arm for the Services and will replace the Sten gun. The weapon fires the international 9 mm. ammunition at a cyclic rate up to 575 rounds per minute. It is accurate at 200 yd., and is also lethal at greater ranges although no claim for accuracy is made beyond 200 yd. At 6 lb., it is claimed to be lighter than any similar type of weapon.

Coal-Handling Plant. Imperial Chemical Industries Ltd., have placed an order with RICHARD SUTCLIFFE LTD., Horbury, Wakefield, for the supply and erection of a coal-handling plant at Billingham-on-Tees. The equipment to be supplied includes five 36 in. wide belt conveyors, two plate feeders and two wagon tipplers, together with crushers, hoppers and structural steelwork.

Power-Station Plant. Contracts have been placed during August by the Central Electricity Authority for power-station plant and equipment amounting, in the aggregate, to £5,943,000. The principal orders include:—for Goldington power station, Bedford: A cooling tower, with FILM COOLING TOWERS (1925) LTD. For Willington "A" power station, near Derby: Low-pressure pipework and valves, with AITON & CO. LTD. For Rogerstone power station, Monmouthshire: Two reinforced-concrete cooling towers, with FILM COOLING TOWERS (1925) LTD.; ash and dust-handling plant, with BABCOCK AND WILCOX LTD., and a chimney, with J. L. KEIR & CO. LTD. For Elland power station, Yorkshire: Two 550,000 lb. per hr. boilers, with JOHN BROWN LAND BOILERS LTD. For Ferrybridge "B" power station, Yorkshire: A 760,000 lb. per hr. reheat boiler, with BABCOCK & WILCOX LTD.; a cooling tower, with DAVENPORT ENGINEERING CO. LTD., and a reinforced-concrete chimney with TILEMAN & CO. LTD.

Arc Furnace. An order has been placed by the South African Iron & Steel Industrial Corporation Ltd. (ISCOR) with D. DRURY & CO. LTD., agents for the ELECTRIC FURNACE CO. LTD., Weybridge, Surrey, for a 60–65 ton Efco-Héroult arc furnace rated at 15,000 kVA. The transformer will be located underground with the secondary leads brought up through a busbar tower. This greatly enlarges the area of unencumbered floor space. The complete equipment will be supplied by the Electric Furnace Co. Ltd., the furnace itself being built in South Africa by the EAST RAND ENGINEERING CO., under the supervision of D. Drury & Co. Ltd. The main electrical equipment will be manufactured in England by the ENGLISH ELECTRIC CO. LTD.

Herald Aircraft. The first British order for the new 44-seat Herald four-engined air liner produced by HANDLEY PAGE LTD., Cricklewood, London, N.W.2, has been placed by Air Kruise Ltd., an associate company of Silver City Airways. The air line is to buy not fewer than six Heralds for the further development of coach-air-rail travel between London, Paris and Brussels. It is hoped that the first machines will be delivered in 1957.

Viscount Aircraft. Three further Viscount 800-series air liners have been disposed of by VICKERS-ARMSTRONGS LTD., Vickers House, Broadway, London, S.W.1. The client is Fred Olsen Airtransport Ltd., Norway. The total number of Viscounts of all types sold is 239. The Olsen 800-series aircraft have been given the type number 805 and delivery is for the autumn of 1957.

Rail Wagons. The British Transport Commission have placed a contract for two 40 ton flat trolley wagons with HEAD, WRIGHTSON & CO. LTD., Thornaby-on-Tees. The wagons will be 58 ft. long over headstocks and fitted with two 54 ft. longitudinal baulks over which the load is spread. The wagons will be used principally for carrying bulky machinery and awkwardly-shaped loads which cannot be carried on ordinary rail wagons.

Automatic Telephone Equipment. The Government of Malta have entrusted STANDARD TELEPHONES & CABLES LTD., Connaught House, Aldwych, London, W.C.2, with a contract for the provision of a new automatic telephone exchange, to be known as "Central," in Valetta. The work involves the manufacture and installation in a new two-storey building, of some 4,300 lines of automatic switching plant; together with a six-position manual board, power plant, and all ancilliary equipment.

Iron-Ore Blending Plant. Ilva Altifoni e Acciaierie d'Italia, Genoa, have placed a contract with the FRASER AND CHALMERS ENGINEERING WORKS of the GENERAL ELECTRIC CO. LTD., Magnet House, Kingsway, London, W.C.2, for a Robins-Messiter ore-blending plant to be installed at the firm's Piombino Steelworks. The equipment is designed to feed iron ore of two sizes into four blending piles arranged in pairs. This is accomplished by two double-wing travelling stocking trippers at the rate of 400 tons an hour. Each pile has a capacity of 11,900 metric tons. A reclaiming machine spanning the width of the ore bed and consisting essentially of a reciprocating harrow and a plough conveyor, will deliver the blended ore at the rate of 400 tons an hour to main conveyors placed outboard of the piles, for delivery to the furnace plant or, alternatively, to auxiliary storage. Electric control gear for the equipment will be supplied by the Witton Engineering Works.

THE PRODUCTION AND DISTRIBUTION OF ELECTRICITY

TENTH CONGRESS OF UNIPEDE

The tenth congress of l'Union Internationale des Producteurs et Distributeurs d'Energie Electrique, commonly and conveniently known as Unipede, opened on September 19 in London under the presidency of the Rt. Hon. Lord Citrine, P.C., K.B.E., the chairman of the Central Electricity Authority. This was the first visit of the congress (which is held every third year) to Britain since it was formed in 1925. During the four days of working sessions, which were followed by study tours, 41 papers and reports were given covering many aspects of electrical production and distribution. Some items from these reports are summarised in this article. Further reference to the congress is made in Weekly Survey notes in this issue.

THERMAL STATIONS

The committee studying aspects of thermal generation, under the chairmanship of Mr. G. R. Peterson, Generation Operation Engineer, Central Electricity Authority, delivered one general and six detailed reports on some special points. In the first, Mr. R. Boudrant, of Electricité de France, discussed the possibilities of a thermal station operating on both coal and heavy oil, both from the view of initial cost and of operational problems. Final choice would have to depend on local conditions, as there were so many variable factors.

The possible uses of fly-ash were the subject of the second report, made by Mr. G. Van Antro of the Société de Traction et d'Electricité of Belgium. The profitable disposal of the vast quantities of fly-ash now being produced by the use of pulverised fuel and of lower quality coals, offered a desirable method of reducing costs and handling problems. In France, handling and transport alone cost 400 francs per ton and a 200 MW station might produce 400,000 tons per annum. In Great Britain where about 6 million tons of fly-ash have to be disposed of every year, the cost was some 2·4 milliards of French francs, or about £2·4 million.

Among the useful components of fly-ash, the composition of which is given in the accompanying table, may be included aluminium, iron, copper, titanium, strontium and germanium.

Analysis of Fly-ash; Europe and U.S.A.

SiO_2	17·3–63·6
Al_2O_3	9·8–58·4
Fe_2O_3/FeO	2–43·6
CaO	0·12–16
MgO	0·06– 5
Na_2O	2– 6
SO_3	0·12–28
C	0·37–64
GeO	0– 1

For the first five of these, no satisfactory method of extraction has been evolved, but for the last, fly-ash forms the principal source in Great Britain, and as much as 100 tons of germanium metal can be produced in a year. In addition, the similarity in composition between fly-ash and cement suggests that it could be used in the manufacture of concrete. This has been done in many places, possibly chiefly in the U.S.A., with quite satisfactory results. Such a concrete will set under water but appears to take rather a long time to reach its full strength; figures given for one particular mixture are 5 kg. per square centimetre at seven days rising to 130 kg. per square centimetre at one year. Fly-ash has also been used successfully in making bricks and building blocks in Belgium, Germany and Great Britain. Yet another use is for the improvement of land, and an experimental station for this purpose has been set up near the Hams Hall power station.

Dr. Ludwig Spennemann of the Vereinigte Elektrizitätswerke Westfalen A.G. of Dortmund, reported on experience of using slag-tap methods of firing—that is the method in which the slag is removed from the furnace in a liquid state. This has come more into use in recent years and has the advantages that a flatter efficiency curve is produced and that much of the fly-ash tends to agglomerate, which makes it easier to handle and dispose of. Disadvantages are that a certain amount of heat is lost with the slag and the removal of it requires some expenditure of power. All the types of furnace described were capable of burning a wide range of fuels, and a fusible slag could be obtained by a suitable mixing of the coal fired. The main gain in efficiency is due to the excellent combustion that can be obtained and to the fact that this can be done with only a very small amount of excess air. The problems of fouling under long periods of continuous operation are still being worked on.

Two forms of pollution can occur with power stations—atmospheric and effluent, and these were dealt with respectively in papers by Mr. G. R. Peterson and Dr. H. E. Crossley, and by Mr. Peterson and Mr. F. F. Ross, all of the staff of the Central Electricity Authority. Atmospheric pollution is caused by the emission of dust or grit and sulphur fumes from the chimneys; and is largely dealt with by installing electrostatic precipitators or scrubbers. A disadvantage of washing the gases is that they are thereby cooled and so do not rise so high above the chimney, tending to give a local concentration instead of being dispersed in the upper atmosphere. The scale of the problem is enormous, for a modern station can burn some 5,000 tons of coal a day, resulting in about 525 tons of ash leaving the combustion chamber Even with cleansing that is 98 to 99 per cent. effective, this results in between 5 and 10 tons of dust being emitted per day. Fortunately intensive field tests have shown that this is sufficiently widely dispersed—when using a high chimney, of the order of 300 ft., and comparatively hot gases—to show very little change in the normal rate of deposition around the power house, or even for some miles down wind. Sulphurous gases are not so easily dealt with, but again in this case, tests have shown very little change in the degree of local pollution after a power station has been started up.

Effluents from a power station may be divided into two categories: first, cooling water, large in quantity and warm, but chemically relatively clean; and other effluents, resulting from boiler blow-down, softening plants and the like, which may be chemically contaminated. The problem of cooling water must be handled in view of local conditions, depending on the sources of supply and the quantity of flow, if from a river. A certain amount of heating can be tolerated by most aquatic life without harm, salmon and trout possibly being the most sensitive. As far as has been ascertained, the loss of oxygen in the condensers is not large and is somewhat balanced by the churning of the water at both intake and outlet. It is expected that discharged water will contain 90 per cent. of the oxygen prior to intake or at least 90 per cent. of the saturation figure, whichever is the less. Water from cooling towers may contain a high percentage of salts due to successive concentration; this can be overcome by suitable purging. The use of " mixed " cooling systems—those in which the flow to a condenser consists of at least 10 per cent. fresh water and at least 10 per cent. recirculated from the cooling towers—is wholly beneficial when the river is at all polluted. Effluents that have become chemically contaminated must be treated according to the chemical concerned. The opposite problem of the effects on the equipment of the power station of using polluted water must also be considered. Synthetic detergents present in the combined state at the intake may be released during purification and cause frothing at the outlet—sometimes even to such an extent as to cause a local nuisance.

To be continued

BRITISH ELECTRICITY SUPPLY

SATISFACTORY PROGRESS AND DEVELOPMENT

The seventh Annual Report and Statement of Accounts of the British Electricity Authority for the year ended March 31, 1955, was published by H.M. Stationery Office, on Tuesday, September 27, and records a year of satisfactory progress and development. We give below some extracts of those portions of the report which deal with technical matters of various kinds. Other matters are referred to in a leading article on page 441.*

On March, 31, 1955, the Authority owned 294 power stations with a total installed capacity of 20,173 MW, of which 19,909 MW was operated by steam and 173 MW by water power. During the year under review generating sets with an aggregate capacity of 1,526 MW and boilers with a total evaporative capacity of 14,827,500 lb. of steam per hour were added. Some 56 MW of uneconomic generating plant, and boilers with an output of 912,500 lb. per hour were shut down. Of the new stations, at which operation was started during the year, Drakelow A (Burton-on-Trent) uses steam at 1,500 lb. per square inch and a temperature of 1,050 deg. F. The same steam conditions are employed in a new section added to Stourport B. The units installed in these two stations are the first with these steam conditions to be operated in this country. At the end of March, 1955, 31 new stations, 7 new sections and 40 extensions of existing stations, with an aggregate installed capacity of 11,730 MW, were under construction or planned, so that by the end of 1960 the output capacity should be increased to 26,650 MW.

* *British Electricity Authority, Seventh Report and Statement of Accounts for the Year ended March* 31, 1955. H.M. Stationery Office [10*s*.].

AVAILABILITY AND SHORTAGES

The present reduction in generating capacity due to breakdown, overhaul and other causes during Mondays to Fridays of December and January—when the demand is normally greatest—fell from 12·4 per cent. in 1953–54 to 11·3 per cent. in 1954–55. In spite of the rate of installation of new plant being the highest ever recorded it was still below that originally planned; and it is estimated that if there had been extremely cold weather in the middle of December, 1954, there would have been a shortage of some 2,200 MW. Actually, the maximum potential demand occurred on January 20, 1955, and amounted to 17,200 MW, or 900 MW more than that of the previous winter. The demand supplied by the plant available was 16,255 MW, the difference being the amount by which it was estimated the load was reduced by low frequency and decreased voltage. The margin of available generating plant is therefore, it is pointed out, precariously small, although it was only necessary to cut off supplies on one occasion, compared with nine in 1952–53.

POWER STATION PLANNING, DESIGN AND LAYOUT

In addition to the programme of nuclear power station building, which has already been described in ENGINEERING, investigations were completed into the potentialities of pumped-storage schemes at six sites. Of these one near Blaenau Ffestiniog was found to be suitable for a scheme of 300 MW,

and powers authorising its construction were sought. A further assessment was made of the Severn barrage project, but no case was established for its construction in the near future. Negotiations were conducted with five firms for the supply of steam from back-pressure generating plant in the Authority's stations without much progress being made.

To ensure economy in the design and layout of power stations the sizes of the main buildings relative to plant capacity are being reduced. Light-weight cladding is being used for inland stations, and at High Marnham the five 200 MW sets are to be arranged end-to-end instead of transversely. Further work was carried out on the development of centralised control for power station plant and studies continued into the capacity of turbine room cranes, from which it appeared that a crane for the heaviest lift—the generator stator—is justified having regard to the incidence of breakdown of this part of the plant.

LARGER EQUIPMENT

The programme for 1960 includes one 100 MW, seven 120 MW and two 200 MW units. Good progress was made with the design work of the last of these units, which will incorporate a number of novel features. They will be supplied from boilers of twin-furnace design with assisted circulation, the re-heat pressure being 490 lb. per square inch absolute at the turbine exhaust, and the final feed temperature being 460 deg. F. Feed heating will be effected in six stages. By using cold-reduced grain-oriented steel it will be possible to employ one three-phase unit as the generator transformer.

Cracks in heavy steel castings, such as turbine cylinders and valve chests, were discovered on 22 machines, and because of the failure of the end rings on two overseas alternators, it was decided to examine the rings of similar dimensions on the Authority's larger machines. Ten of the 74 rings thus treated were found to contain cracks of varying degree. The larger diameter rings on 27 machines were changed for others of a less highly stressed type.

The results of trials at six power stations indicated that different types of boiler could operate without fouling when using coal of low chlorine content and low or medium sulphur content. In another case it was found that hard deposits were formed on the boiler and superheater tubes after burning coal of medium chlorine content with the addition of small quantities of coal of high sulphur content.

Full-scale trials of methods of alleviating fouling and corrosion showed that by rough blending the coal tipped to the bunkers, up to 40 per cent. of coal of high chlorine content could be burnt without detriment to boiler operation. The humidification of pulverised fuel flames, as a means of alleviating fouling, was found to be successful, but the employment of the same method on stoker-fired boilers resulted in no material improvement.

ENGINEERING RESEARCH

It is the duty of the Authority to conduct research into matters affecting the supply of electricity, and among the projects in this field recorded in the report mention may be made of the systematic examinations which were carried out at a number of power stations to ascertain the effects of variations in methods of firing and in operating conditions on efficient combustion. For this purpose a modern boiler is being specially equipped with supplementary recording instruments to obtain comprehensive data.

The dispersal of gases from chimneys, as influenced by velocity, temperature and meteorological conditions, was further studied, and new techniques were developed for tracing and simulating the fall-out of dust particles of various sizes. Progress was made towards discovering the water temperatures which can be borne without harm by certain species of fish, and it was established that in most cases the tolerable temperatures are at least as high as those caused by the discharge of circulating water into rivers.

Early in 1955 a 100 kW wind-power generator was brought into operation in parallel with the grid near St. Albans, but the local winds were inadequate for it to be determined whether it would be capable of generating its full output if conditions permitted.

Laboratory trials were made on 380 kV insulators, and tests were carried out to estimate the resistance to corrosion and abrasion of the armouring proposed for the projected 132 kV cross-channel cables.

* * *

Obituary

MR. EDMUND SAYERS

We regret to record the death on September 20 of Mr. Edmund Sayers, until 1953 manager of the Aero Equipment Sales Department of the British Thomson-Houston Company, Limited, at Coventry.

Born in 1885 at Brighton, Mr. Sayers received his training at the Technical College there and joined B.T.H. in 1905, entering the meter test department. In 1910 he moved to the Supply Department at Rugby, which department handled the sales of meters and instruments. As foreign export representative he travelled widely until the outbreak of war in 1914, at which time the production of meters was discontinued, and the Coventry factory concentrated on producing aircraft magnetos. In 1932 Mr. Sayers was appointed manager of the section which later became known as the Aero and Auto Equipment Sales Department. While holding this position, he visited aircraft establishments in North America, acting as representative of the Aircraft Accessory Manufacturers Association. He also served on several committees of the S.B.A.C. and was a member of the Aircraft and Advisory Panel.

* * *

We also regret to record the death of:

LIEUT.-COLONEL WILLIAM FRENCH, C.B.E., D.S.O., M.C., which occurred on Sunday, September 18. After acting as Clerk to the Western District Committee of the Stirling County Council he served throughout the 1914-18 war with distinction. On demobilisation he held important posts in the civil adminstration of Iraq, and in 1929 he joined the staff of the Department of Technology of the City and Guilds of London Institute. He became Superintendent five years later, a position he held until 1949, when he was elected a Member of the Council.

* * *

LAUNCHES AND TRIAL TRIPS

M.S. "SIMBA."—Single-screw cargo vessel, with accommodation for twelve passengers, built and engined by Burmeister and Wain, Ltd., Copenhagen, for the East-Asiatic Co., Ltd., Copenhagen, Denmark. Main dimensions: 456 ft. between perpendiculars by 62 ft. 6 in. by 38 ft. 3 in.; deadweight capacity, about 10,300 tons on a draught of 27 ft. 3 in. B. and W. seven-cylinder single-acting two-stroke Diesel engine, developing 9,870 i.h.p. at 115 r.p.m., arranged for burning Diesel oil or boiler fuel. Speed, 16·8 knots. Delivered, August 16.

S.S. "HELDIA."—Single-screw oil tanker, built by Swan, Hunter, and Wigham Richardson, Ltd., Wallsend-on-Tyne, for Shell Tankers, Ltd. (Marine Managers for the Anglo-Saxon Petroleum Co., Ltd.), London, E.C.3. Main dimensions: 530 ft. between perpendiculars by 69 ft. 3 in. by 39 ft.; deadweight capacity, about 18,000 tons on a draught of 29 ft. 7⅛ in.; gross tonnage, 12,000; oil-tank capacity, 17,470 tons. Double-reduction geared steam turbines, developing 7,500 s.h.p. at 100 r.p.m. in service, constructed by the Wallsend Slipway and Engineering Co., Ltd., Wallsend-on-Tyne. Steam supplied by two Babcock and Wilcox oil-burning boilers constructed by the Wallsend Co. Service speed, 14½ knots. Launch, September 2.

M.S. "DONA MYRTO."—Single-screw oil tanker, built and engined by William Doxford and Sons, Ltd., Sunderland, for the Compañia Panamena Europea Navegacion Limitada, Panama. (Agents: Chandris (England), Ltd., London, E.C.3.) Second of two tankers for these owners. Main dimensions: 505 ft. by 69 ft. 9 in. by 39 ft.; deadweight capacity, 16,700 tons on a draught of about 30 ft.; gross tonnage, about 11,200. Doxford five-cylinder opposed-piston oil engine. Launch, September 5.

M.S. "RED ROSE."—Single-screw trawler, built by John Lewis and Sons, Ltd., Aberdeen, for the Lago Steam Trawler Co., Ltd., Fleetwood, Lancashire. Main dimensions: 135 ft. between perpendiculars by 26 ft. 6 in. by 13 ft. 3 in.; fishroom capacity, about 9,300 cub. ft. Five-cylinder Diesel engine, developing 800 b.h.p. at 250 r.p.m., constructed by British Polar Engines, Ltd., Glasgow. Launch, September 6.

"SHEARWATER" LIGHT VESSEL.—Built by Philip and Son, Ltd., Dartmouth, to the order of the Commissioners for Irish Lights, Dublin. Last vessel of a series of three. Main dimensions: 136 ft. 5 in. overall by 25 ft. by 15 ft. The lantern provides a beam 40 ft. above sea level, visible for about ten miles in clear weather. Delivered, September 9.

S.S. "CORSTREAM."—Single-screw collier, built by the Burntisland Shipbuilding Co., Ltd., Burntisland, Fife, for William Cory and Son, Ltd., London, E.C.3. Main dimensions: 320 ft. between perpendiculars by 46 ft. by 22 ft. 4 in.; deadweight capacity, 4,640 tons on a draught of 20 ft. 3 in. Direct-acting triple-expansion steam engine of reheat design, developing 1,100 i.h.p. in service, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Sunderland. Steam supplied by two multitubular oil-burning boilers. Trial trip, September 10.

M.S. "MOUNT EVEREST."—Single-screw trawler, built by John Lewis and Sons, Ltd., Aberdeen, for the Seafield Fishing Co., Ltd., Aberdeen. First vessel to be built under the White Fish Authority's grant and loan scheme, for Aberdeen ownership. Main dimensions: 120 ft. between perpendiculars by 25 ft. by 12 ft. 6 in.; fishroom capacity, 7,000 cub. ft. Mirrlees six-cylinder direct-drive and direct-reversing Diesel engine, developing 650 b.h.p. at 250 r.p.m., constructed by Mirrlees, Bickerton and Day, Ltd., Stockport, Cheshire. Trial trip, September 14.

M.S. "SEYYID KHALIFA."—Twin-screw vessel for the carriage of nine first-class, 16 second-class and 350 deck passengers, and cargo. Built by Philip and Son, Ltd., Dartmouth, to the order of the Crown Agents for Oversea Governments and Administrations, Millbank, London, S.W.1, for service between Zanzibar and Mombassa and Zanzibar and Pemba. Provided with special state apartments to enable the vessel to be used by H.H. The Sultan of Zanzibar as a private yacht. Main dimensions: 200 ft. between perpendiculars by 38 ft. by 15 ft. to main deck. Two six-cylinder marine Diesel engines, together developing 2,000 b.h.p. at 300 r.p.m., constructed by British Polar Engines, Ltd., Glasgow. Launch, September 15.

S.S. "PANAGHIA."—Single-screw oil tanker, built by the Furness Shipbuilding Co., Ltd., Haverton Hill, County Durham, for Porto Alegre Compania Naviera S.A., Panama. Main dimensions: 560 ft. between perpendiculars by 80 ft. by 42 ft. 3 in.; deadweight capacity, about 24,800 tons on a summer draught of about 32 ft. 4 in.; oil-tank capacity, 23,500 tons. Double-reduction geared steam turbines, developing 7,300 s.h.p. at 100 r.p.m. in service, constructed by Richardsons, Westgarth & Co., Ltd., Wallsend-on-Tyne. Steam supplied by two Foster Wheeler oil-burning boilers. Speed, 14¼ knots. Launch, September 15.

S.S. "BARON GLENCONNER."—Single-screw cargo vessel, built by the Caledon Shipbuilding and Engineering Co., Ltd., Dundee, for H. Hogarth and Sons, Ltd., Glasgow. Main dimensions: 430 ft. between perpendiculars by 58 ft. by 37 ft. 6 in. to shelter deck; deadweight capacity, 9,500 tons on a draught of 25 ft. 3 in.; gross tonnage, 5,468. Triple-expansion steam reciprocating engine, working in conjunction with a Bauer-Wach exhaust turbine and developing 3,350 i.h.p., constructed by John G. Kincaid & Co., Ltd., Greenock. Steam supplied by three oil-fired boilers. Speed, 12½ knots. Trial trip, September 15.

M.S. "REAVELEY."—Single-screw cargo vessel, built and engined by Swan, Hunter, and Wigham Richardson, Ltd., Newcastle-upon-Tyne, for the Whalton Steam Shipping Co., Ltd. (Managers: Stephens, Sutton, Ltd.), Newcastle-upon-Tyne. Main dimensions: 435 ft. between perpendiculars by 60 ft. by 39 ft. to shelter deck. Swan Hunter-Doxford four-cylinder combined-stroke oil engine, developing 4,400 b.h.p. at 115 r.p.m. in service, and arranged for burning boiler fuel. Launch, September 15.

S.S. "KELLY."—Single-screw trawler, built by Cochrane and Sons, Ltd., Selby, Yorkshire, for Derwent Trawlers, Ltd., Grimsby. Main dimensions: 137 ft. 6 in. by 28 ft. by 14 ft. 3 in.; gross tonnage, about 440. Triple-expansion steam engines, constructed by Amos and Smith, Ltd., Hull. Steam supplied by one oil-burning boiler. Launch, September 19.

Book Reviews

UTILISING SOLAR RADIATION

Solar Energy Research. Edited by FARRINGTON DANIELS and JOHN A. DUFFIE. *The University of Wisconsin Press, 811 State-street, Madison, Wisconsin, U.S.A.* (4 dols.)

Solar radiation is the source of almost all forms of energy used by mankind for heating and power generation, exceptions being nuclear energy, tidal power, and the internal heat of the earth. The conventional energy sources—coal and oil—have been concentrated by natural processes. Fuels represent a concentration in time; for a mass of coal that may be burnt in a few seconds has been formed by years of photo-synthesis in the original plant, apart from the millions of years required for the metamorphosis to coal. Water and wind power, due to the steady action of solar radiation over large areas of the earth, have been concentrated in limited areas either by recondensation of the water vapour or by accumulated pressure differences. These latter forms of energy are mechanical and the inescapable toll of the Carnot cycle has been supplied by natural processes; although their intensity is relatively low, they may be converted to mechanical or electrical power at high efficiencies.

It is inevitable that with the incessant search for extensions of energy sources, direct solar radiation has lately received considerable attention. Some 50 to 100 years ago solar energy problems were studied to a considerable extent, but the time was not then appropriate for such developments. The increasing scarcity and cost of fuels, however, have recently stimulated active interest in the direct use of solar radiation, and although much of this started in the United States of America there are many other centres of research distributed over the globe.

The popular impression of solar energy is of large mirrors concentrating the radiation upon steam boilers and driving engines. This was the general pattern of research some 50 years ago, but it is now realised that solar power on a large scale is still very far distant. Here again it is the toll of the Carnot cycle that reduces the efficiency of such processes to a figure incompatible with the capital expenditure. The present applications of solar energy are more concerned with the production of low-grade heat, i.e., heat energy at temperatures below the normal boiling point of water. Even if nuclear power were to provide an abundance of electrical energy in the future, it would be wasteful to degrade this to low temperatures if other forms of such energy were available. There is also scope for solar energy at the other end of the temperature scale, where limited amounts of heat are required at very high temperatures.

The coming World Symposium on Applied Solar Energy, to be held in Arizona from October 31 to November 5, lends an air of topicality to this report of a similar symposium held two years ago. It is a record of the proceedings of a symposium held at the University of Wisconsin, Madison, U.S.A., in September, 1953, and organised by Professor Farrington Daniels, chairman of the Department of Chemistry. This symposium was intended to bring together in an informal manner scientists and engineers working on solar energy problems, in order to review past accomplishments and present progress, and to discuss future possibilities of application. The contributions of 31 authors represent many points of view and cover the entire range of solar energy applications. In presenting this summary, reference will not be made to any one author but a general impression given of the scope of the book.

A review of expected world energy demands, taking into account the increasing population over the next hundred years, suggests that by this time solar energy might provide nearly 10 per cent. of the world's energy in the form of low-grade heat, but only 0·1 per cent. in the form of mechanical power. Such an estimate is itself sufficient justification for promoting present research on solar energy utilisation. Since solar radiation is the raw material for power, a study of solar physics and meteorology is essential. World data on insolation are scant and incomplete, and much research is needed to augment this and to determine those regions where applications would be economically favourable.

Space heating and hot-water supply are great consumers of low-grade energy and this is a field in which solar energy applications are most successful at present. A number of experimental houses heated by solar radiation have been constructed in the United States and solar water heating is a proved success in many areas. The heat collectors are of the flat-plate type, i.e., a blackened metal surface with heat insulation at the back, and covered by one or more sheets of glass, facing the sun. This collector is fixed in position on the roof of the house and some 50 to 60 per cent. of the incidental radiation may be recovered by a working fluid circulating in contact with the metal surface. Air or water may be used as the circulating fluid, and heat storage effected by water, crushed rock or gravel, or the fusion of crystalline sodium sulphate. A combination of solar energy collectors with heat-pump operation is also a promising field for development.

Solar power, as mentioned in the prefacing remarks above, is still far from being realised on a large scale. Most designs employ mirror concentrating systems with steam as a working agent, and an output of 1 h.p. has been attained for 50 sq. ft. of mirror area. Although the flat-plate type collector operates at lower temperatures and consequently at a reduced thermal efficiency for power generation, improvements in design might enable 1 h.p. to be developed by 200 sq. ft. of surface area during daylight periods. Volatile liquids, e.g., ammonia, Freon, or sulphur dioxide, could be used as working fluids with some practical advantage. The hot-air engine is another possibility. Thermo-electric and photo-voltaic generation of electrical power are fully discussed, though the spectacular development of the Bell silicon photo-electric cell was announced after the conference. Such devices would be limited at present to the small powers needed for operating radio and telephonic equipment. Solar furnaces are used to attain temperatures of the order of 3,000 deg. C.; the largest at present in existence is the 35 ft. diameter mirror furnace constructed by M. Trombe at Mont Louis. There are, however, a number of other installations with which valuable research is being conducted on the properties of materials at high temperatures. At present, the cost and intermittent working periods of such installations do not compare favourably with normal methods for melting at more moderate temperatures.

In the general field of agricultural applications, pastural farming, etc., a simple form of solar still which collects the condensed vapour on sloping glass covers required no attention, and would have wide application in arid farmland areas for the production of potable from brackish water. More elaborate designs are under test for the supply of drinking water to inland populations, and research may also improve the rate of evaporation from brine concentrating pools. The photo-synthesis of vegetable material occupied an important part of the conference; the problem is whether or not the naturally occurring process can be accelerated by artificial means. The efficiency of fixation of radiant energy as carbohydrate is quite high when based on the light energy impinging on an individual cell. Under laboratory control conditions it may be as high as 30 per cent., but under natural circumstances it is very much lower, probably only 0·1 per cent. for crops when based on the ratio of the yield per acre and the yearly insolation on this area. Rapid growth of algae may be promoted by warmth and increasing CO_2 in a circulating system exposed to radiation, but though this process may be beneficial for growing food, it would not be economical for fuel production. Photo-chemical utilisation of light energy presents a wide field for research; this implies a chemical system in which equilibrium is shifted by the action of light, so that the products would be separated and subsequently recombined with the liberation of energy. Alternatively, products of the light reaction could recombine immediately, but the energy produced would be conducted to an external circuit.

Thus the symposium covered almost all the aspects of solar energy research which are at present being investigated, though perhaps one might have expected more discussion on the possibilities of using solar energy for refrigeration and air cooling in the tropics, a field in which there are urgent requirements. At the conclusion of the volume there is a survey of United States patents prepared by Mr. John A. Duffie of the University of Wisconsin (co-editor of the volume with Professor Daniels), and an extensive bibliography.

The contributions are written in an easily readable style with adequate illustrations, and the volume as a whole can be recommended as giving the best outline that is available of present activities in solar energy utilisation.

Foundation Engineering: A Survey of Modern Practice in the Solution of Foundation Problems of All Kinds. By ROLT HAMMOND. *Odhams Press, Limited, Long Acre, London, W.C.2.* (21*s.*)

It will be said, perhaps, that the application of engineering principles to the founding of buildings and engineering works upon all sorts of ground resolves itself into the study of a number of individual problems, a view which is confirmed by the fact that much of the literature on the subject is in the form of isolated papers and little has been done to collate this material. It must be admitted, however, that these individual problems have a common basis in the science of soil mechanics, a knowledge of which is essential for the proper study of any one problem; and while the contributory factors and circumstances may vary, much may be learnt from a general study of the subject and of the methods applicable to problems other than that with which the reader has immediate concern. Mr. Hammond has, therefore, done good service in writing this book, which provides a comprehensive picture of the entire field.

The author deals with each phase from the simplest beginnings, and makes a clear exposition of the basic principles the starting point of each argument. Although written primarily for engineers and dealing with his subject in terms appropriate to the requirements of practical design and construction, he has at the same time been careful to give his work a definite value to the young engineer, for whom an unusually varied collection of data is provided. On the theoretical side, a working knowledge of elementary physics and of simple equations will suffice for a thorough grasp of the nine chapters into which the book is divided.

In the arrangement of the work two objects are clearly discernible, the first being that of bringing the general principles of soil mechanics into close relation with the various techniques of exploring a particular site. These considerations start with the classification and physical characteristics of soil, as a preliminary step to the explanation of how the load-bearing capacity of certain kinds of soil may be improved by grouting with cement, bituminous emulsions, and other mixtures. In Chapter 2, on the question of site exploration, the utility of soil mechanics is further exemplified by reference to the use of the diamond drill in the work of borehole testing, and to the more recent methods of geophysical exploration by measurement of the variation of gravity and of electrical resistivity, and by the procedure of seismic refraction. Here the student will come to appreciate the

practical scope of each of these methods, the circumstances in which any one of them may be expected to yield the desired results with the minimum expenditure of time and labour. The electrical-resistivity method, for instance, which is to be recommended on sites where the superficial deposits are of fairly uniform composition, has the advantage of being quicker and less expensive than the seismic procedure. Furthermore, a resistivity survey is specially useful in locating and tracing bed-rock in the case of heavily jointed and broken strata, and also in delineating areas of pronounced fissuring and in detecting cavities near the surface.

The second aim which can be noted is the discussion of numerous practical points which have arisen in particular classes of work. In this part of the treatment, which occupies the remaining 150 pages of the book, separate chapters are devoted to the matter of foundations for heavy machinery, houses, commercial and industrial buildings, bridges, and maritime structures. Here the author summarises the art, which includes the underpinning of ancient buildings, with a wealth of photographic reproductions, line drawings, and descriptions of noteworthy undertakings in this country and abroad. The field is vast, and some compression is inevitable. For this reason the book is essentially one for the engineer or architect who wishes to see his existing knowledge of the subject in a general setting and to become acquainted with methods and ideas which experience has shown to be of value in arriving at a decision on the relative merits of alternative schemes in the case of peculiar or difficult sites.

★ ★ ★

BOOKS RECEIVED

Some of the books noticed here are selected for extended review in ENGINEERING.

A History of Firearms: From Earliest Times to 1914. By W. Y. CARMAN. *Routledge and Kegan Paul, Limited*, 68-74 *Carter-lane, London, E.C.4.* (16*s.*)

A book on cannon, machine guns, muskets and rifles, pistols and revolvers up to the outbreak of the first World War. The author is a member of the staff of the Imperial War Museum, and he does not limit firearms to weapons carried in the hands or arms, but includes heavy artillery in accordance with the dictionary definition of a firearm "a weapon from which missiles are propelled by the combustion of gunpowder or other explosive." The book is illustrated by a number of black-and-white sketches.

Gas Turbines and Jet Propulsion. By G. GEOFFREY SMITH. Sixth edition. Revised and enlarged by F. C. SHEFFIELD. Published for "Flight" by *Iliffe and Sons, Limited, Dorset House, Stamford-street, London, S.E.*1. (35*s.*)

After outlining the principles and history of jet propulsion and the turbine engine, the author deals in a general manner with the performance, design, components, combustion, fuel systems, metallurgical problems, research, testing and maintenance of aircraft gas turbines. He then describes British and Canadian, American, and European engines, followed by chapters on compounded units, ramjets, pulsejets and rockets, and rotating wing propulsion. Gas turbines for road vehicles and other applications are covered in the last two chapters. Early British developments are described in an appendix.

Combustion Researches and Reviews, 1955. Published for and on behalf of the Advisory Group for Aeronautical Research and Development, North Atlantic Treaty Organization, by *Butterworths Scientific Publications*, 88 *Kingsway, London, W.C.*2. (35*s.*)

The following subjects are covered by papers published in this volume: diffusion flames in the laboratory; the combustion of sprays; the combustion of liquid fuels; the formation of combustible mists; the correlation of combustion efficiency and injector characteristics under simulated altitude conditions; flame stabilisation and propagation in ramjet combustors; stability limits in relation to the resistance of obstacles to flow; the mechanism of carbon formation; similarity analysis for chemical reactors; flame radiation and similarity; and the role of wake transition in flame stabilisation on bluff bodies. Three of the 14 papers are in French, the remainder in English.

BRITISH ASSOCIATION MEETING AT BRISTOL

ACCELERATING CHARGED PARTICLES: AIR TRANSPORT

Continued from page 419

Session B on Monday morning, September 5, was concerned with the acceleration of charged particles, two papers being presented on this subject. The first was by Mr. C. W. Miller, M.Sc., F.Inst.P., of the Research Department, Metropolitan-Vickers Electrical Company, Limited, and was entitled "Linear Acceleration of Charged Particles to High Energies." We published part of this paper on page 340 of our issue of September 9, and it is completed in the issue for September 16, on page 374. Dr. S. F. Dorey, President of the Section, occupied the chair. The author gave a summary of his paper, in the course of which he showed a film of a model in the Science Museum designed to illustrate the motion of charged particles on a travelling wave. In the model the waves are formed in a horizontal rubber band and the particles are represented by steel balls placed on it. Some of the balls appeared to travel from one end of the band to the other, but some were apparently missed and failed along the band.

LINEAR ACCELERATION OF CHARGED PARTICLES TO HIGH ENERGIES

At the conclusion of Mr. Miller's remarks, the chairman asked whether, in the case of the 4 MeV linear accelerator referred to in the paper as being used for detecting flaws in steel objects up to 13 in. in thickness, it was possible to move the apparatus, or whether it was necessary to bring the objects up to it for examination. In reply, Mr. Miller said that at present an object to be examined had to be brought to the apparatus, but there seemed to be no reason why one of the accelerators should not be made transportable, in the sense that it could be taken to a factory, possibly in a furniture van. If the van had a girder on which the equipment could be run out it could be taken into the factory and the radiography done there.

Dr. Dorey further inquired if there would still be good penetration in the case of a number of plates in series with an air space between them. This, Mr. Miller replied, raised the question why it was necessary to use high-energy radiation. The higher the energy, up to a certain value, the better the penetration and the greater the thickness of steel that could be penetrated. For example, if 4 MeV radiation were passed through 1 in. of steel its intensity would be only reduced by one half. This had an advantage and a disadvantage; large thicknesses could be dealt with but the contrast of the radiograph would be low. This was a disadvantage in some cases but a blessing in others, in that it enabled samples with large variations in thickness to be dealt with on the same film. A further advantage of high-energy radiation was the reduced scatter.

Professor J. Greig asked what proportion of the electrons was actually trapped in the different types of linear accelerators and Mr. Miller replied that he could best answer that by quoting figures from his own Company's equipment. In the 4 MeV accelerator about one third of the electrons injected were trapped, the reason that it was only one third being that some entered on the wrong phase. If any electrons were lost it should be at the very beginning of the machine and not later after energy had been imparted to them. When a machine had to be manoeuvrable its length was restricted but in the case of a fixed machine, the length of which was unimportant, it was possible to design the input part to collect a higher percentage of the electrons. In the optimum design it should be possible to collect over 320 deg. of the 360 deg. of phase, i.e., nearly all the electrons.

Mr. A. F. M. McQuarrie, the last speaker in the discussion, asked if there were any difficulty in insulating the supports for the accelerator tube. In reply, Mr. Miller said they were not insulated; there was a straight metallic connection. This did have a distorting effect to some extent, which could, however, be taken up by the variation of other quantities.

This completed the discussion and the chairman proposed a vote of thanks to the author, which was carried by acclamation.

CIRCULAR ACCELERATORS FOR NUCLEAR PARTICLES

When the session was resumed after an interval, the chair was taken by Professor J. Greig, who after introducing the author, Mr. J. B. Adams, of the Proton Synchrotron Division of the European Council for Nuclear Research, Geneva, invited him to present his paper entitled "A Review of Accelerating Machines for Nuclear Particles." The paper, which dealt chiefly with cyclotrons, synchro-cyclotrons, synchrotrons and the alternating-gradient synchrotron, will appear in a subsequent issue of ENGINEERING. Mr. Adams presented it in a somewhat abbreviated form, but at his conclusion insufficient time remained for general discussion.

In proposing a vote of thanks, Professor Greig said the audience had greatly appreciated the high quality of the paper and the lucid outline given of the physical background underlying the operation of the machines. In addition, Mr. Adams had done something in which Section G was greatly interested, in that he had outlined the engineering problems associated with the machines and had done that in relation to what might be termed the unit cost of the machines themselves. It had possibly not been appreciated, until Mr. Adams had made the point, that the machines were in fact purely tools for the research work of the physicists. In some ways they were comparable with very large telescopes and were an example of the call which physics had made on engineering resources for structures which were quite exceptional from a wide variety of points of view.

The vote of thanks was accorded with acclamation and the session concluded.

GEOLOGY, SOIL MECHANICS AND CIVIL ENGINEERING

On Monday morning, September 5, a special joint session was held between the Engineering Section and Section C (Geology) in order to consider the relationship between geology and civil engineering with special reference to the subject of soil mechanics. Mr. W. N. Edwards, President of Section C, took the chair, and after thanking the members of the Engineering Section for their attendance, called on Mr. F. H. Edmunds, M.A., of the Geological Survey, to give the first paper on "Geology and Site Investigations," which was of an introductory character.

Mr. Edmunds said that all civil engineering work involved local disturbance of the rocks of the earth's crust, either by excavation or loading, or, perhaps most frequently, by both. The engineer, in order to appreciate the likely reactions of the rocks to his activities, required as full geological information as possible concerning a new site. This was particularly so in regard to (1) characteristics of rocks as determined from small samples—their hardness, cohesion, porosity and the like; (2) the arrangement of rock masses and strata within the earth's crust—whether they were lying horizontally or inclined, were buckled or folded, etc.; and (3) the potentialities of water storage in, and movement through, the rocks.

On the whole, civil engineers throughout the ages had adequately summed up the potentialities of their sites by using commonsense observation, although failures were by no means uncommon. In some instances that method of approach was still quite effective, but in general it would now prove to be inadequate for two reasons: (1) through advances in technique and in machinery many civil engineering works of to-day were immensely larger and more complex than those of past time, and (2) whereas the old engineers often had a choice of site, present-day work often had to be constructed at sites imposed on the engineer. These might be on alluvial tracts in coastal areas or in other difficult situations where ground was occupied by thick beds of unconsolidated material, in many instances saturated with water.

To the engineer's assistance geology had come as an organised science and the point might be illustrated by a simple example. In 1948, a new gasholder was projected for the town of Harrogate. A convenient site was chosen but before work was commenced a detailed geological investigation was made. This showed that if the gasholder were to be erected on the selected site it would rest partly on a dipping bed of sandstone and partly on an underlying bed of clay. Obviously there would have been different reactions to the pressure of the weight imposed. The sandstone would be rigid and the clay would yield under compression, with the probable disruption of the structure along the line of junction. As a result of the geological investigation the site was moved to an area wholly on clay to a sufficient depth for settlement to be uniform, but the question then arose as to what degree compression would be likely to take place, a question of a type which, as far as geology is concerned, would lie directly within the sphere of a specialised application of physics to sedimentary petrology.

It was desirable, Mr. Edmunds continued, to look at petrology as it had been some 30 years ago. A great deal of detailed knowledge on hard rocks had been accumulated but the petrology of soft sediments had only recently been tackled and there was then no co-ordinated information to answer questions of the kind noted above. In these circumstances, engineers and physicists, basing their work on sporadic theoretical and experimental attacks made during the previous two centuries, set out to get information of the kind required. From their work the science of soil mechanics had evolved and this, subsequently, made important contributions to civil engineering practice. Among its direct contributions to geological science was a new light on the mechanics of landslips. The word "soil" in this connection connoted soft and unconsolidated material irrespective of its thickness or its depth below ground surface. It had little connection with the top several inches of the earth's crust associated with agriculture. Generally speaking, what the engineer called "soils" were the soft rocks of geological terminology, but the essential feature of them was that they were unconsolidated. The name "soil mechanics" had occasioned much discussion and in some respects it was unfortunate; "geotechnique" had been suggested as an alternative and had much to commend it. Much of the work of soil mechanics investigations was a matter of physics, undertaken in the laboratory and involving an examination of small samples. Laboratory tests by themselves, however, were incomplete; in order to obtain the fullest information from them they required to be related to the stratigraphy of the beds from which they were taken. To-day, soil mechanics (or geotechnique) must be regarded as a meeting place of geology, civil engineering, physics and mineralogy. As such it formed a fitting subject for a joint discussion.

After Mr. Edmunds's paper had been delivered three other papers were presented by their authors as follows: "The Fundamentals of Soil Mechanics," by Mr. P. L. Capper; "Soil Mechanics and Railway Civil Engineering," by Mr. A. H. Toms; and "Soil Mechanics Aspects of the Design of Foundations," by Mr. F. D. C. Henry. Mr. Capper's paper was published in our issue of September 9, on page 348; Mr. Toms' in September 16, page 384; and Mr. Henry's in September 23, page 413.

After all the papers had been presented no time remained for general discussion. The chairman therefore proposed a vote of thanks to the authors, which was duly carried, and the session terminated.

THE NEW RECORDER

Two papers concerned with air transport were included in the programme for Session A on Tuesday, September 6, the last day of the meeting. Before proceeding with the main business, the chairman, Dr. S. F. Dorey, announced that Professor W. Fisher Cassie, who had carried out the duties of Recorder of the Section for the usual period of five years, would complete his term of office at the end of the Bristol meeting. During his period of office the work of the Section had proceeded very smoothly. His own work as President, he said, had been greatly eased by his officers and committee, and particularly by the Recorder, and on his own behalf, as well as on that of the members of the Section, he wished to thank Professor Cassie for all he had done. Professor J. Greig, of King's College, London, he added, had been invited to carry on the duties of the Recorder and had accepted the invitation. Dr. Dorey concluded by thanking him for having done so.

RECENT PROGRESS IN BRITISH AIR TRANSPORT

The first paper on the programme was entitled "Recent Progress in British Air Transport" and was by Mr. Peter G. Masefield, M.A., F.R.Ae.S., Chief Executive of British European Airways. In introducing the author, Dr. Dorey mentioned Mr. Masefield's new appointment with the Bristol Aeroplane Company which had been announced in the Press on the previous day. In responding, Mr. Masefield said it was a particular pleasure to him that the meeting of the British Association was being held in Bristol this year. He was not sure which "hat" he was supposed to be wearing, but whichever it was it came to the same answer in the matter of air transport, in respect of which we were in a very exciting stage.

Mr. Masefield then delivered his paper which he illustrated by numerous slides of graphs and photographs, adding greatly to its interest. We published the later part of the paper in our issue of September 16, on page 366. At its conclusion the audience expressed their appreciation by applause and the chairman then invited discussion. The first speaker, Wing-Commander T. R. Cave-Browne-Cave, asked for the author's views regarding the transport of passengers between London Airport and the City centre. It seemed to him that with the traffic congestion that was bound to occur at the airport for a considerable time it would become increasingly difficult to handle this traffic by helicopter.

The author agreed that the problem was a very serious one. The B.E.A., he said, were carrying two million passengers this year and five years hence they would be carrying about four million annually. The resulting bottleneck could be appreciated when it was remembered that passengers were travelling 25 miles in an hour to the airport, whereas in the next hour they travel any distance up to, say, 500 miles. The helicopter, he said, was not the answer to the problem; its function was to convey traffic from city centre to city centre over distances such as that from London to Birmingham. He believed the answer to the problem of conveying traffic from city centre to airport lay in the development of rail transport and he suggested that the possibilities of the monorail for this purpose should be examined closely. An overhead suspended car designed on aerodynamic principles and running on pneumatic tyres might travel at speeds of 180 miles per hour and make the journey from London centre to the airport in about five minutes, which no helicopter could do. At the moment, London Transport were considering an extension of the District Railway to the airport.

Mr. L. H. Pretty asked if anything could be done to enable British manufacturers to produce larger batches of aircraft initially in order to ease the problem of tooling-up. To this, Mr. Masefield replied that it was a question of the depth of the market, which was growing very rapidly. The Viscount and the Britannia afforded examples of this. About 240 Viscounts had been sold and about 500 would be sold eventually. The Britannia was a larger aircraft, but he saw no reason why its sales should not reach several hundreds because the market was growing continually. Once an aeroplane like the Britannia was established, as the Viscount had become established, he believed the orders would increase and the production rate would be raised so that it would not be necessary to give a two-years quotation for delivery. Only a week before, the B.E.A. had placed orders for more Viscounts but would not get them for two years.

Mr. J. Rosen asked whether in designs now being dealt with consideration had been given to the use of new metals such as titanium, and the author replied that a great deal of titanium was now being used in military aircraft and it was beginning to be used in civil aircraft. The whole of the nacelle of the DC-7 was now in titanium. He believed its use would extend and its cost would come down.

Replying to a speaker who asked why it was necessary to modify aircraft as they were made, Mr. Masefield said that development was a great problem; as soon as an aircraft design was "frozen" the engine manufacturer would announce that he had developed an engine of less weight and consuming 10 per cent. less fuel than an earlier design. Then followed the process of matching the engine to develop its capabilities. The airlines had, perhaps, been guilty of not saying exactly what they wanted in the early stages. To-day they were considering aeroplanes with 100 or even 130 seats. There was no doubt that larger aeroplanes would come; the congestion at airports was so great and traffic was moving so fast that it was necessary to move it in larger units. If an airline had a Viscount with 70 seats, they could use it much more economically between, say, London and Paris than they could use two aircraft each having 47 seats. Aircraft development had to move stage by stage as engines developed; production had to be kept going and the air liners had to be kept flying. The Douglas Company had demonstrated that philosophy; they had developed a series of machines each one faster and carrying more passengers than the one which preceded it.

Another speaker asked if there were not a danger that with the development of aircraft the airports would be out-dated and would require runways of excessive length. The construction of the runways to take the loading imposed upon them might also be a serious civil engineering problem. To this Mr. Masefield replied that the development of aircraft having an improved power/weight ratio and the application of the "blow and suck" principle were means of easing the runway problem; he did not think that longer runways would be needed. He agreed that the question of their strength was important as aeroplanes were getting larger. The DC-8 would weigh about 150 tons, which would be carried on eight main wheels and four nose wheels; so that the bearing loads would be heavy. Concrete on aprons, however, was relatively cheap.

Mr. S. L. Whitby asked for information about the training of operators and maintenance staff, and Mr. Masefield said that good skilled engineers were at a premium everywhere and were wanted both by manufacturers and airline operators. An encouraging feature, however, was the extended life between overhauls of the modern aero-engine and airframe, although they were more complex and the demands on the electricians were greater than formerly. The general ten-

dency, however, was for the number of man-hours per flying hour to go down. With the "docking" system, as used to-day, whereby the aeroplane came into a "dock" provided with pneumatic, hydraulic and other equipment to enable the wings, engines, etc., to be removed easily and quickly, the time for major overhauls could be reduced from 21 days to five days, so that an aeroplane could come in on Monday and be completed by Saturday.

Mr. C. G. Mills inquired if the "blowing and sucking" device had a large influence, and Mr. Masefield said he wanted to use it as much as possible. There were, however, two points about it which he might mention. The propeller-turbine engine had not the excess air available to give the degree of "blow and suck" that the jet engine could give. The main field for "blowing and sucking" was therefore the military field. If, however, the military could develop the system to be really reliable, civil operators would try as quickly as possible to improve the economics of the transport aeroplane. He hoped, however, that they would use it to reduce the approach speed and to effect shorter runs at landing and take-off rather than to use smaller wings, etc.; also that they would try to improve regularity and reliability by the device rather than to obtain too great an economic advantage at the beginning; that, he considered, would come later.

To a speaker who asked about the suitability of delta-wing aircraft for the Atlantic crossing, Mr. Masefield replied that the delta wing was not very suitable for carrying passengers. Firstly, the angles of take-off and landing were very extreme, and secondly, the delta wing had to be flown very high (50,000 ft. or more) if it were to be really economic. Pressurisation problems at that height were very considerable and, moreover, passengers liked to look out of the aeroplane, so that he felt that from the civil-flying point of view the delta wing was not engaging the attention of operators at present.

This completed the discussion, and the President then thanked the author for what he described as his delightful lecture. The meeting, he said, had enjoyed it not only from the point of view of the progress recorded but also from the information given regarding the economic aspect, which was a prime factor in all development. He concluded by wishing Mr. Masefield success in his new appointment.

EFFECTS OF TURBINE ENGINES ON CIVIL AIR TRANSPORT DESIGN

The second paper, bearing the above title, was prepared by Dr. W. J. Strang, Chief Designer to the Bristol Aeroplane Company, Limited, for fixed-wing aircraft, but as Dr. Strang was unable to be present the paper was presented by Dr. A. E. Russell, Chief Engineer and Director of the company. The paper, which will be published in a forthcoming issue of ENGINEERING, discusses the problems and opportunities which arise from the introduction of gas-turbine engines into air transports and the resulting changes in design.

Dr. Dorey, who again took the chair, then invited discussion on the paper, and the first speaker, Mr. C. G. Mills, asked Dr. Russell to review the reasons for the failure to take advantage of blowing and suction. To this Dr. Russell replied that suction must be distributed fairly uniformly over the whole surface of every component of which it was desired to reduce the drag. If the proportions of air drawn from each side were in error all the desired gain would be lost. The problem was connected with weight distribution and it was doubtful whether the complication justified the net result. Blowing, however, was relatively simple; there were no engineering or mechanical difficulties about it which could not be solved.

Mr. S. L. Whitby raised the question of the noise of aircraft and asked if there were any hope for the ordinary civilian in this respect. In reply, Dr. Russell said that an extensive programme of research into the noise problem was being carried out. The noise of the turbo-jet could be reduced quite significantly by introducing vortex generation which changed the frequency of the sound. This could not apply if jet engines had to employ afterburning, but it was most unlikely that jet engines using afterburning would be allowed to operate near built-up areas. The noise from propellers was not very bad now, and as the speed of turbo-propeller aircraft increased the noise at take-off was likely to become less.

Mr. L. H. Pretty said that in recent French designs the engines were mounted at the rear of the fuselage and he invited Dr. Russell's comments on this point. Replying, Dr. Russell said the engines were placed in this position primarily to give a clean wing. The American solution was to sling the engines underneath the wing, but that, at least to the eye, was a rather "dirty" aerodynamic arrangement, although it was not so bad as it appeared to be. The best solution was to take the engines away from the wing altogether. Engine jets placed behind and above the wing were in a favourable position for obtaining the maximum ram and as they were also well aft of the body the cabin should be unusually quiet. A difficulty was that rubbish thrown up by the wheels at take-off might represent a considerable hazard and unless proper stone-guards were introduced it would probably be regarded as too dangerous on that account.

The chairman, who was the last speaker on the paper, said, as one whose work was connected more with the sea than with the air, he would like to raise one or two points to show the difference between the marine side and the air side in the matter of fuel consumption and engine life. In marine work, using large reciprocating oil engines, the fuel consumption was of the order of 0·32 lb. per shaft horse-power per hour and in Dr. Strang's paper there were figures approaching 0·4 lb. of fuel per effective horse-power per hour. He asked if Dr. Russell would give the difference in fuel consumption between the three types of engine mentioned—the turbo-prop., the supercharged turbo-prop., and the turbo-jet—and would also give an idea of the respective lives of the three types.

In marine work it was necessary to design for a life of, say, 20 years and that, of course, imposed a limit in regard to efficiency and from the point of view of the temperature of the metal employed in the manufacture of the parts. It did not affect the reciprocating engine so much but it did affect the behaviour and life of the gas-turbine. Ten years ago gas-turbines were being demonstrated in the United States at San Francisco to show how well they could be operated and how soon they would be used in ships, but none had been put into a ship "worth talking about" there. In this country we had only two gas-turbine engines worth mentioning used for ships, one of them for light craft and one in the Auris which had run continuously from this country to Curaçao and back in 24 days. There was to be a 2,000 b.h.p. gas-turbine in a similar ship which would have an efficiency of, say, 25 per cent. and a fuel consumption 50 per cent. of that of an oil engine at the present time.

In his reply, Dr. Russell said that a jet engine did not give horse-power—only thrust; but he would quote fuel consumption in terms of horse-power for the turbo-prop. The jet engine would have a pressure ratio of about 12 : 1, which represented good present-day development standards. He assumed that the compressor and turbine efficiencies were about 90 per cent. For the pure jet engine he must quote a forward speed because the efficiency varied with this. At a speed of 600 m.p.h., the fuel consumption was about 0·95 lb. of fuel per hour per pound of thrust, and with the by-pass engine that figure was reduced by about 7 per cent. to 0·88 lb.

In the case of the turbo-prop. engine, multiplying the horse-power by the efficiency, he would take a propeller efficiency of 90 per cent. for low speeds; but with aircraft, the propeller efficiency at 500 m.p.h. was more nearly 75 per cent. Taking that figure, the consumption of the turbo-prop. engine, with the same pressure ratio and component efficiencies as for the turbo-jet, was about 0·6 lb. of fuel per hour per pound of thrust. If the turbo-prop. engine were used as a horse-power producing machine the fuel consumption would come down to about 0·35 lb. per horse-power hour which was rather lower than a figure quoted in Mr. Masefield's paper.

The question regarding the life of the different types of aero-engine was rather difficult because he suspected that, unlike other forms of commercial engines, they did not necessarily finish up as the same engines after three or four overhauls. New engines going into service normally had an overhaul life of about 600 hours, which could rise to 1,500 hours with modifications and experience. He did not know what proportion of parts had to be replaced at each overhaul, but the turbine engines would probably have new combustion chambers. Probably there would be five overhauls during the life of a turbine engine, but under the conditions he had been describing, at 400 m.p.h., the mileage was probably not very different from that of other commercial engines.

The chairman, after remarking that the life of the high-speed reciprocating oil engine was probably very much less than that of the older engines, thanked Dr. Russell for the able manner in which he had presented the paper and requested him to convey to Dr. Strang the thanks of the Section for having prepared it. This concluded the business of the session and the meeting terminated.

To be continued

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INCREASED SAFETY FOR WELDERS

Voltage Divider in Power Circuit

Arc welding in confined spaces has always been a dangerous job, and a device to reduce the danger has recently been produced by Philips Electrical Limited, Century House, Shaftesbury-avenue, London, W.C.2. The device is a low-voltage safety relay which ensures that at no time, except when the arc is being ignited or is burning, is a full open-circuit voltage available.

The type PE.3100 relay is essentially a voltage divider which reduces the full open-circuit voltage of the power service, either alternating current or direct-current, by 50 per cent. As soon as the electrode is brought into contact with the workpiece the splitter is by-passed and full voltage is available for striking an arc. A simple delay device holds the open-circuit voltage to full value for 1 second after the arc is extinguished; this allows re-striking should the arc be broken accidentally, and permits tacking of the workpiece without re-operating the main relay.

The equipment can be fitted to the output side of either alternating-current or direct-current welding plant up to a capacity of 500 amperes; it measures 14 in. by 7 in. by 7 in. high. In the case of multi-operator plant the relay must be installed between each regulator and its electrode holder. A local power supply of 220 volts alternating current is required which can generally be obtained from the input panel of the plant.

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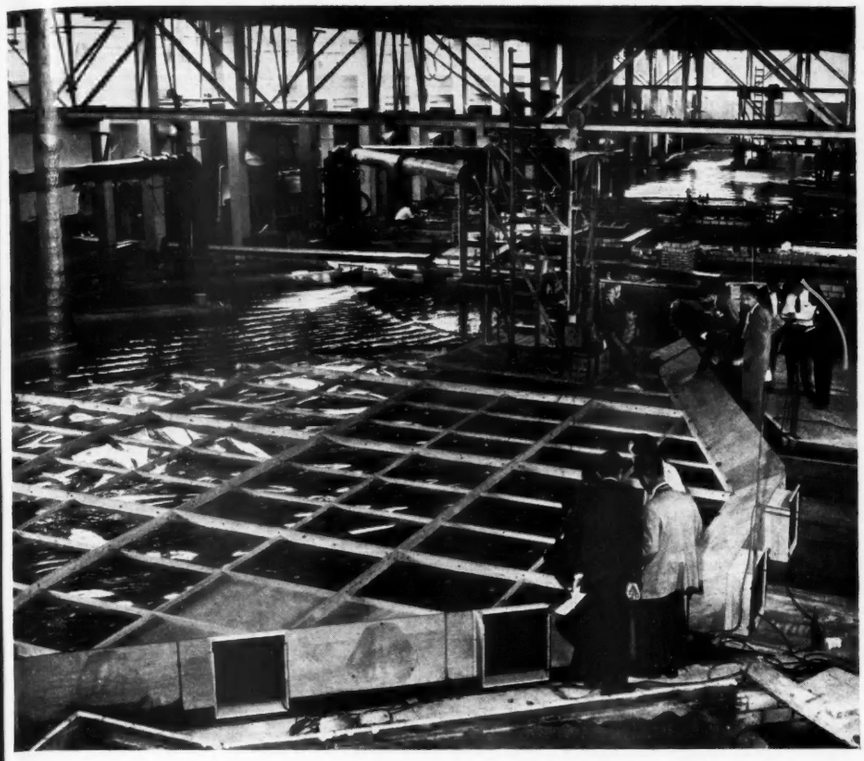
SEALED RELAYS

A range of sealed relays particularly for use in aircraft has been announced by Measuring Instruments (Pullin) Limited, Winchester-street, London, W.3. Both 2 and 4 pole types are made, the maximum current ratings being respectively 25 and 10 amperes. To meet with the arduous conditions of high-altitude flight they have been satisfactorily tested to withstand forces of up to 20*g* and vibrations of 0·003 in. amplitude at 250-8,000 cycles per minute. All types of sealed relay can be wound for working voltages of 12, 24, 50, 112 or 240 direct current. Contact speeds are 16 milliseconds from break to make with current on and 20 milliseconds with current off. Over 200 of the relays have been specified for each Bristol "Britannia" 300 LR.



A model designed to investigate the action of the North Sea swell in the Gooerese Gat, off the Dutch coast. The swell is initiated by three wave-makers, and wind is simulated by suction fans drawing air under the transparent covering.

HYDRAULIC RESEARCH

INTERNATIONAL CONGRESS AT THE HAGUE

The Sixth International Congress on Hydraulic Research, which was held in Holland, with headquarters at The Hague, from August 31 to September 6, was more largely attended than any that has been held since the foundation of the International Association for Hydraulic Research, at the instigation of Professor W. K. A. Fellenius, of Sweden, 20 years ago. Twenty-seven nations were represented and more than 80 papers were discussed, and it was noticeable that the technical sessions were as fully attended at the end of the programme as they were at the beginning, a feature which does not always characterise international congresses, especially in fine weather.

The opening session was held in the morning of Wednesday, August 31, in the Ridderzaal, the historic hall in which Her Majesty the Queen of the Netherlands meets her Parliament, the chair being taken by the President of the International Association for Hydraulic Research, Professor L. G. Straub, of the University of Minnesota, in the presence of Mr. J. Algera, Minister of Transport "and Waterstaat"—a Dutch term which hardly admits of exact translation, but which comprehends the construction of dykes as well as the control of the water and waterways behind them.

On behalf of the Municipality of The Hague, an address of welcome was delivered by the Deputy Burgomaster on behalf of the Burgomaster—who, unfortunately, was prevented by ill health from being present. In the course of this address it was mentioned that a scheme was well advanced to pipe the water of the Rhine into the sand dunes near Scheveningen, whence it would be pumped out again for the supply of the surrounding district.

The Minister of Transport, who spoke in English, welcomed the delegates to the Congress on behalf of the Government of the Netherlands. Holland, he said, depended more than most countries on the results of hydraulic research, and was glad to take advantage of the skill of experts from other countries. The Association, he recalled, originated in 1935, when the International Navigation Congress was meeting in London, and owed its inception primarily to Professor Fellenius, whom he was glad to see present, and to Professor Meyer-Peter, of Zürich, who unfortunately was unable to attend. The Netherlands had not been well represented at the previous Congress, held in Minneapolis, as the Dutch engineers were then fully occupied in repairing storm damage to their sea defences. Since then, they had been proceeding rapidly with the reclamation of the Zuider Zee, which was still their main preoccupation. He wished the Congress wisdom to solve their problems and a succession of discussions that would open up new vistas of prosperity.

The Minister then formally declared the Congress open.

The President, in response, thanked the Minister and the Deputy Burgomaster for the welcome extended to the Congress, and congratulated them and their country on the progress made with the draining of the Zuider Zee, which was adding many thousands of acres of agricultural land to the Netherlands. The study of tidal hydraulics, he mentioned, was the most important of the subjects to be discussed, and was one of particular significance to the Dutch people, whose New Waterway carried the biggest annual tonnage of shipping of any in the world.

Professor J. H. Thijsse, the secretary of the International Association, who spoke in French, expressed the pleasure of the Dutch engineers to see the Congress so well attended. The response had, indeed, threatened to tax rather severely the accommodation available in the newer polders, which they were to visit, but he had no doubt that the delegates would accept any slight personal inconvenience in a sporting spirit, and he was confident that they would find much of interest in their tour.

The afternoon of August 31 was devoted to the first of the technical sessions, which discussed the hydraulics of outlet works, to which further reference will be made; and on the following morning the delegates visited the Hydraulics Laboratory, over which Professor Thijsse presides, at the Technical University at Delft. There they saw eight models of estuaries, etc., of varying sizes, particular interest being shown in a model designed to investigate the action of the North Sea swell in the Gooerese Gat, off the Dutch coast. This model, which has a horizontal scale of 1 : 1,250 and a vertical scale of 1 : 250, is unusual, if not unique, in that it is covered entirely by plastic sheets to reproduce the effect of local winds over the flats. The covering, at a height of about 1 ft. above the water, is of transparent material, so that the wave formations can be observed. Three wave-makers initiated the swell, and the wind conditions were produced by suction fans, drawing the air under the plastic covering. The positions of these fans along the boundary of the model can be seen in the accompanying illustration.

Other models seen in operation included one of the delta of the Rhine and the Maas, to show the effect of the proposed enclosure works on the tidal movements. The horizontal and vertical scales were 2,400 and 64, respectively, and the time scale was 300. Of a different character was a model of the ferry harbour at Breskens, a small Dutch port which, incidentally, was commented upon by John Smeaton in his diary of a visit which he paid to the Low Countries exactly 200 years ago; the projected harbour, it was found, would be subject to the action of waves penetrating directly from the North Sea, but there were other difficulties in adopting a proposed alternative plan. The model was intended to enable a comparison to be made between the two schemes. Yet another model was designed for the study of the bedload movement at a bifurcation of the Rhine; the horizontal and vertical scales were 160 and 60, and the time scale of the bedload movement, one year to 26 hours.

From Delft the delegates returned to The Hague, where the afternoon was spent in discussing a series of papers on tidal hydraulics. In the evening, they were the guests of the Government of the Netherlands and the Municipality of The Hague, at a reception and buffet supper in the Ridderzaal.

To be continued

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RAW MATERIAL FOR PAINT AND PLASTICS INDUSTRY

Monsanto's New Plant

Monsanto Chemicals Limited announces that it has authorised expenditure of more than £500,000 for the construction of a new plant to manufacture phthalic anhydride at its Newport, Monmouthshire, factory. The new plant is expected to be in operation towards the latter end of 1957. Representing a very substantial addition to the company's present output of phthalic anhydride, which has been manufactured at its Ruabon factory since 1936, the new plant will bring the company's total production of this raw material up to about 15,000 tons yearly.

The decision to provide the additional capacity is the result of the steadily increasing demand from the British paint, plastics and related industries, which export a high proportion of their products. Direct export of part of the additional phthalic anhydride production is also envisaged. Phthalic anhydride is used in the manufacture of polyester resins; of alkyd resins used in many types of surface coatings and industrial finishes; in the manufacture of phthalic esters used as solvents, plasticisers and insect repellents; in the production of numerous pharmaceuticals and dyestuff intermediates.

SOIL MECHANICS ASPECTS OF THE DESIGN OF FOUNDATIONS*

(2) DISTRIBUTION OF PRESSURE AT FOUNDATION LEVEL

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Concluded from page 416

It is commonly assumed in the design of foundation structures that the bearing pressure distribution at the soil/foundation contact surface is uniform or uniformly varying (Fig. 3 (*a*)). For at least several decades it has been known that bearing pressure distribution for a rigid foundation located at ground level reaches a maximum beneath the centre of the foundation when the soil is cohesionless and a maximum at the edges when the soil is cohesive (Fig. 3 (*b*) and (*c*)). The fall in pressure at the edges on cohesionless soil is attributed to lateral movement of particles. It seems likely that lateral flow in cohesive soil may take place over a period of time, thereby leading to a reduction in pressure at the edges but no long-term tests appear to have been made to check this point. In any case the bearing pressure distribution may change to some extent on clay. The effect of these variations in pressure on the design of foundations can be examined theoretically by assuming that, for a footing located on the surface of the ground, the form of the pressure distribution is parabolic in the one case and is either elliptical or conforms to an elasticity equation in the other. When a rigid foundation is located at a depth below the surface of the ground the bearing pressure distribution tends to be more nearly uniform (Fig. 3 (*d*) and (*e*)).

EXPERIMENTAL WORK ON MODEL FOOTINGS

Some experimental work has been done on this problem and Faber[4] (1933) published the results of his experiments with a 12 in. diameter model footing located on Leighton Buzzard sand and on undisturbed samples of blue London Clay. The soil was contained in a box about 2 ft. 6 in. in diameter and 18 in. deep. In order to eliminate completely the effects of confinement on strains in the soil in bearing-pressure experiments the length and breadth of a soil container should be about three times the dimensions of the plate and the depth should be about three times the length of the plate. The proportions of the box used by Faber do not conform to the ideal but the results should not be very different from those which would be obtained under ideal conditions. The exposed surface of the clay was covered with a thin sheet of rubber to prevent desiccation. The model foundation was of composite construction to facilitate the measurement of bearing pressure distribution. The lower plate consisted of five concentric rings, each of which was connected to the top plate by three ½ in. diameter steel rods, together with a central disc connected to the top plate by a single rod. The bearing areas of each of the rings were made equal to facilitate calculations and the area of the disc was one-third that of a ring. The upper plate was solid. The strains in the rods were observed with an extensometer when the foundation was loaded and these were measures of the bearing pressure under each ring and the disc. The investigations were concerned with a foundation on the surface of soil and also at a depth of about 30 ft. below ground level; in order to simulate this latter condition a surcharge of 1·46 tons per square foot was applied over the whole surface of the soil outside the foundation. It was found that the sum of the calculated loads on the rods agreed with the applied load within two or three per cent. The apparatus employed in these experiments and some of the results are shown in Fig. 3 (*f*) to (*k*).

The above discussion has been concerned essentially with rigid foundations; that is, foundations which do not deflect under load. In practice very few foundations can be considered completely rigid, with the exception of piers and deep solid blocks of concrete. However, the proportions of most pad footings are such that under working loads they can be considered to behave as rigid foundations and the bearing pressure distribution under these conditions conforms to one or other of the types discussed above. If a foundation is very flexible then the pressure distribution reaches a maximum beneath the load on all types of soil and the edges may lift clear of the bearing surface. Obviously there is no point in constructing foundations possessing such uneconomical characteristics. The model foundation employed by Faber can be considered to be of the rigid type and the very small degree of flexibility introduced by the top plate and the rods is no more in proportion than that which obtains in practical foundations.

Tests on a concrete footing 3 ft. square by 10 in. thick described by Converse[1] (1933) introduce an interesting factor in connection with foundation design. The footing was constructed in a 3 ft. × 3 ft. × 10 in. hole dug in the bottom of a 4 ft. × 4 ft. × 4 ft. pit. The soil was a mixture of clay, silt and sand. The arrangement of the eleven piston-type pressure cells in the footing is shown in Fig. 3 (*l*). When the load was increased to a value yielding an average bearing pressure of 2·65 tons per square foot, it was found that the total upthrust from the pressure distribution given by the cells was only 55 per cent. of the applied load. Subsequently the soil at the sides of the footing was loosened and it was then found that the total upthrust had increased to 95 per cent. (Fig. 3 (*l*)). From a study of the brief details given in the original paper it seems that appreciable adhesion resistance could have been developed at the sides of the footing, but it is also apparent that initially the cells may have been recording pressures lower than the real values. Consequently the quantitative results are dubious but this brief account of the tests has been included here because of the significance of side resistance in design. The adhesion component of the resistance is greatest when footings are cast against soil and probably constitutes the greater part of that resistance under working loads. The friction component increases considerably in sandy soils as the ultimate bearing capacity of the soil is approached. Side resistance representing 10 to 20 per cent. of the column load materially affects moments and forces on a footing—more particularly the moments—but at the present time this is not taken into account in normal design practice. Obviously research on this topic is desirable in order to determine the magnitude of these effects and a few pilot experiments may be sufficient to demonstrate how significant they are.

MODES OF FAILURE OF FOOTINGS

During the last three decades or so the design of reinforced-concrete column footings has been based on the work of Talbot[14] (1913), who carried out a large number of tests on 5 ft. square footings mounted on a test bed of helical springs and loaded axially through a central 12 in. square column. It was found that, at failure in bending or shear (diagonal tension) or bond, fractures occurred on all four sides of the footing. Consequently, the total bearing pressure employed in the design of each side of the footing is taken as that within the trapezium *aacc* for bending and bond and within the trapezium *bbcc* for shear (Fig. 3(*m*)). In Great Britain the practice is generally to calculate forces and moments on the appropriate trapezium but in the United States semi-empirical rules are employed which reduce the amount of calculation while retaining the essence of Talbot's conclusions.

More recently, Richart[11] (1949) made an extensive study of the problem and employed 7 ft. square footings and also rectangular footings mounted on a bed of helical springs. In these tests it was found that failure in bending occurred on two sides only of both square and rectangular footings and that the bearing pressure causing failure was included in the rectangle *a'a'cc*. It follows that design should be based on the total bearing pressure contained within this rectangle and in the case of square footings both pairs of sides must be designed for the full bending moment since the pair of sides on which failure will occur is unknown. It is theoretically possible to design an axially-loaded square footing such that failure in bending occurs on all four sides at the same instant. Nevertheless, since it is impossible to secure absolute uniformity in the manufacture of column and footing and to guarantee precisely axial loading and, in practice, to ensure a perfectly uniform distribution of bearing pressure because of variations in soil properties, it is likely that incipient failure occurs initially on one or two sides and complete failure follows rapidly through lack of ductility in the concrete. Failures in diagonal tension obtained by Richart were symmetrical and the column, together with a pyramidal block of footing concrete, broke through the footing. It will be realised from this outline of Talbot's and Richart's work that the effect of side resistance—mentioned above in connection with Converse's tests—is not included in normal design practice.

A knowledge of the modes of failure of footings is necessary in order to appreciate the implications of various bearing pressure distributions. The centres of pressure under one-half of a circular footing for given geometrical distributions are readily found from the solids of revolution generated by the various curves. Since a square footing cannot be treated in this way it is necessary and reasonable to assume that the centres of pressure under one-half of such footings will be roughly in the same relative positions for the different pressure distributions. It can be shown that the parabolic distribution leads to a bending moment along the axis *xx* about 15 per cent. less than that given by a uniform distribution. Also that an elliptical distribution leads to an increase of about 10 per cent. and a modified elastic curve distribution to an increase of about 40 per cent. more than that of a uniform distribution. The effect of an eccentric load on a square footing is to distort the symmetrical distribution developed under axial loading so that a maximum pressure is produced on the same side of the footing as the eccentric load and it is reasonable to expect that the variation in bending moment under these different asymmetrical pressure distributions will be of the same order as those quoted above for axial loading, although there does not appear to be any experimental evidence to confirm or to contradict this supposition.

Further evidence of the effect of different pressure distribution has been published by Marshall[6] (1944) who carried out tests on miniature 8 in. square reinforced-concrete footings 1¼ in. thick with an axially-loaded 2 in. square column. Well graded pit sand and moist yellow London Clay were placed separately in a box about 10 in. × 10 in. × 12 in. deep to serve as the foundation soils. Most of the failures appear to have been in diagonal tension although some may have failed in bending tension. The failing load when supported on clay averages about 0·6 that on sand, confirming that there are higher pressures at the edge of the foundation on clay than on sand. The effects of confinement cannot be ignored in these experiments because of the relatively small box used to contain the soil.

More experimental evidence based on larger footings tested on the surface of, and at a depth in, sand and clay and loaded with axial and eccentric loads is desirable before amendments are made to current design methods for which uniform or uniformly varying pressure distributions are assumed. The elimination of restraint due to confinement of the soil is necessary and the results must be carefully analysed in the light of what is known concerning the behaviour of soils under stresses and the modes of failure of footings. In the meantime, overstressing or understressing to the extent of 20 per cent. need not cause undue concern but it is right that the designer should be aware of these effects in order that he may make desirable modifications in special circumstances. Nevertheless, the possible cumulative effects of our ignorance must not be overlooked; it may be that local variations in the soil will increase the bending moment on a particular footing on the surface of clay by, say, 20 per cent., making a total increase of about 40 per cent. above that derived from an assumed uniform pressure distribution. Furthermore, since it is likely that stresses in reinforced-concrete members cannot be determined with a guaranteed accuracy of less than 20 per cent., the final underestimate of stress may be of the order of 60 per cent. Fortunately, a factor of safety of three coupled with plastic flow in the soil and the concrete tend to relieve the possibility of distress in the footing.

These arguments lead to consideration of the possibility of evolving design methods based on concomitant failure of soil and foundation. If the contact pressure at the soil/foundation interface is known when shear failure occurs in the soil, then forces and moments can be computed and the plastic theory for reinforced concrete can be employed for the design of the foundation. Terzaghi (1943) has shown that the bearing pressure distribution beneath a continuous footing with a rough base will have the forms indicated in Fig. 3 (*n*) and (*p*) at failure. The pressure distribution for a foundation on a mixture of cohesive and cohesionless soils has a compound form with components from both basic soil types. When shear failure has occurred in the

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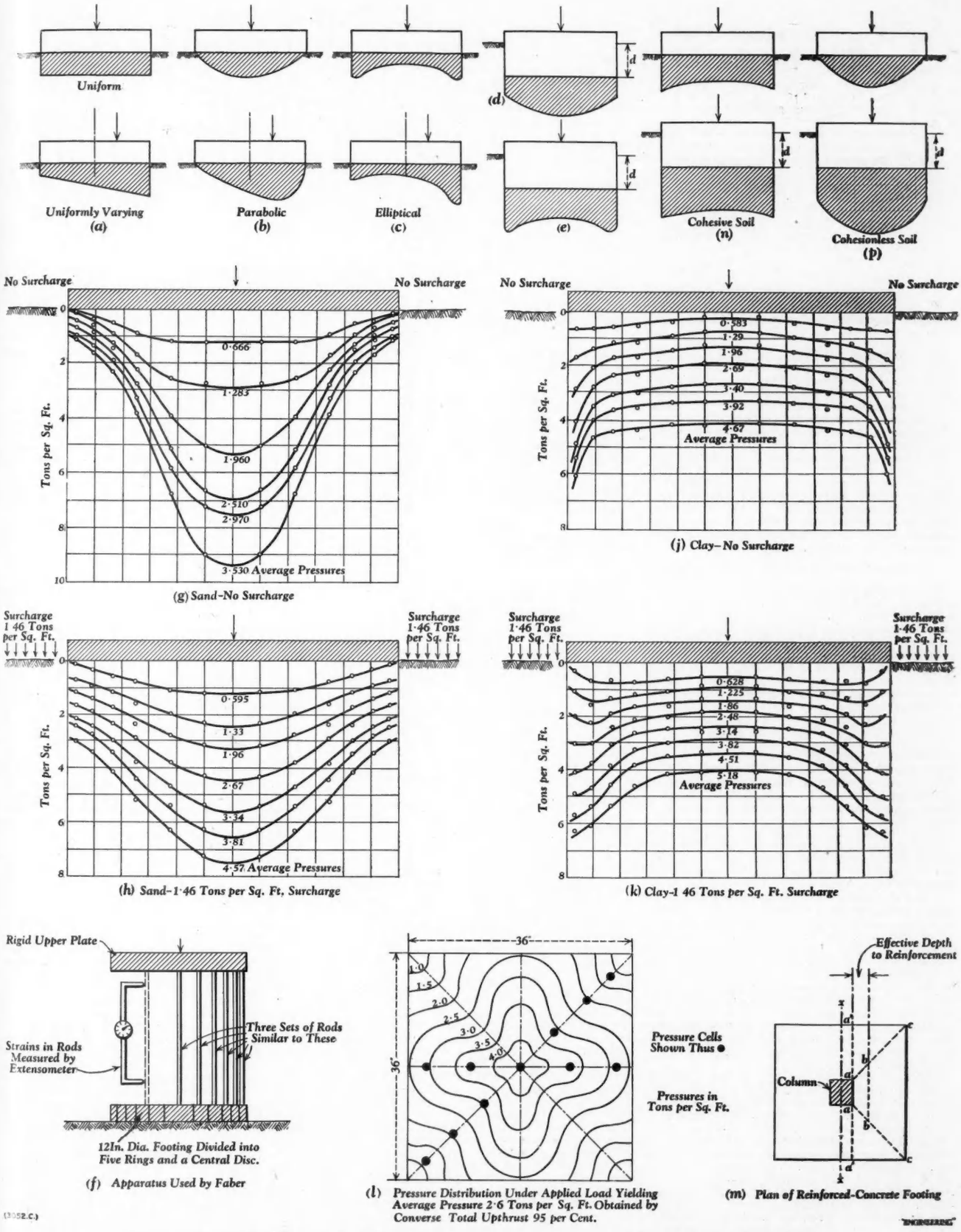
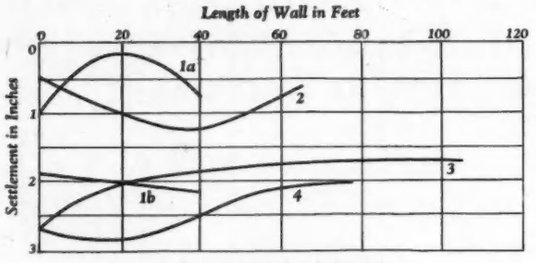
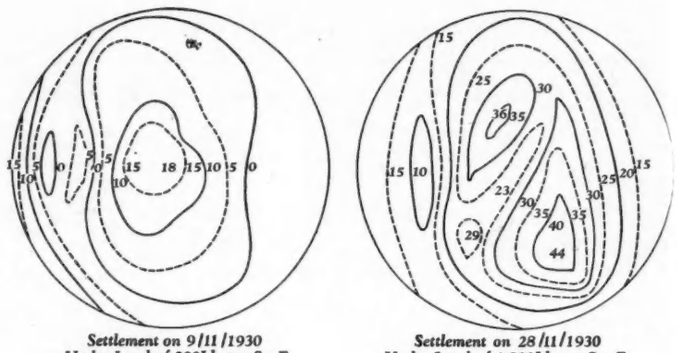


Fig. 3 Pressure distribution at soil/foundation contact surfaces: experimental investigations on square footings. The diagrams at the top of the page indicate differences due to changed loading conditions and different soil types. Variations in the pressure distribution in particular model tests are shown in the other diagrams.



Settlements of Uniformly Loaded Long Narrow Continuous Footings
(a)



Settlement on 9/11/1930 Under Load of 300Lb. per Sq. Ft.

Settlement on 28/11/1930 Under Load of 1,900Lb. per Sq. Ft.

Settlement in mm. of a Flexible Raft Supporting a Tank Containing Fluid. Loading Commenced on or About 4/11/1930 and Increased Uniformly.

(b)

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Fig. 4 Settlements of continuous brick footings and of a flexible raft under a uniform load. The variations in soil compressibility are clearly indicated.

soil, deflection of the foundation has no effect on the distribution of bearing pressure. It is reasonable to assume that the bearing pressure beneath a pad footing will have the same characteristic forms as the pressure beneath a continuous footing and these are not unlike the distributions under working loads. Consequently, the variations of forces and moments on cohesive and cohesionless soil at failure are likely to be of the same order as those under working loads but the effect of side resistance due to friction in sandy soils may affect forces and moments considerably. Here also experimental evidence and theoretical investigations are required to support design methods based on the condition of concomitant soil and foundation failure and the suggestions made above are purely tentative.

CONTINUOUS FOOTINGS AND RAFTS

A continuous footing can be employed to support a wall or a number of columns in a line or a combination of both. In the common method of analysis of a continuous footing it is assumed that the bearing pressure distribution is either uniform or uniformly varying and that this distribution can be derived simply by the application of statics. It is tacitly assumed that the stress/strain relationship for bearing pressure is linear, that the footing functions as a completely rigid body and that the settlement is either uniform or uniformly varying. Several factors conspire to affect this simple treatment.

Firstly, a continuous footing can seldom be treated as a rigid body. Sagging occurs in the footing beneath the columns and hogging between the columns in a manner similar to that of an inverted continuous beam. Furthermore, differential settlements occur from column to column. These effects tend to change the bearing pressure distribution from a linear to a wave form. Bending in a footing may lead to cracking of the concrete; this in turn leads to variations in stiffness of the footing along its length and consequently influences the distribution of bearing pressure.

Secondly, the short-term stress/strain relationship for the soil is not linear although the curve is likely to be most nearly linear up to working loads and within this range can be expressed in terms of a foundation modulus. Site tests for the determination of this coefficient, which is also known as the modulus of subgrade reaction, are usually carried out with bearing plates of width less than the footing width and it is known that the modulus decreases with increasing width of test plate. Consequently plates of large width should be employed and if tests are made at a given site with plates of different widths an estimated value of modulus can be obtained by extrapolation.

Thirdly, although the long-term settlement due to consolidation of cohesive soils may be only partly taken into account in site tests for foundation modulus, it may be an important factor in determining bearing pressure distribution.

Fourthly, it is assumed that the soil is homogeneous and isotropic, whereas variations may occur in soil properties every few feet. The curves shown in Fig. 4(*a*) are taken from a diagram given by Terzaghi[16] (1935) and represent the settlements of long continuous footings uniformly loaded by brick walls. The bearing pressures beneath the walls were based on tests and were conservative. The subsoils beneath footings 2, 3 and 4 were sand or gravel. The differential settlements were due to variations in the compressibility of the soils and the diagram demonstrates that, even under uniform loading, settlement is unlikely to be uniform and hence is incalculable in a practical sense. It is worth observing that none of the walls cracked under these differential settlements.

EFFECT OF FLEXIBILITY

The only alternative analysis to the rigid body method at the present time is that based on the problem of a beam on an elastic foundation. A linear stress/strain relationship for the soil is normally required in this analysis although, with additional computation, the effect of a uniform variation in subgrade modulus along the length of the footing can be taken into account. Several rigorous methods of analysis are available but computations are lengthy. A shorter superposition method can be employed but it has certain limitations. Nevertheless, calculations for typical footings, treated as beams on elastic foundations, reveal that the rigid body analysis may lead to excess reinforcement at certain points and deficiencies elsewhere and it follows that the flexibility of footings ought to be taken into account in design.

A comprehensive method of analysis requires that the flexibility of a footing and both immediate and long-term consolidation settlements be taken into account. The inclusion of the effect of variations in soil compressibility—if they are known from site tests—renders the analysis intractable unless the variation is found to be linear and even then computations are considerably increased. It might be possible to determine a coefficient of variation of compressibility at any given site for which certain arbitrary increases in bending moments and shearing forces in the footing could be made in appropriate designs. On the other hand, it is generally desirable to design for the worst possible circumstances, for which two limiting conditions are usually selected from site data.

RAFT FOUNDATIONS

If it is found during design that the area covered by pad footings exceeds about 50 per cent. of the area of the building, it is usually preferable and more economical to construct a raft foundation. When incorporated in a basement, a raft exhibits two advantages: the bearing capacity is augmented by the amount of the overburden (γd) and the settlement can be reduced to a minimum by arranging the weight of the excavated material to be equal to the weight of the building, if such an arrangement is convenient in the lay-out of the building. During the process of excavation there is a tendency for the soil in the bottom to heave but, depending on the characteristics of the soil, full heave may be practically instantaneous or may take a considerable time to develop. During the construction in cofferdams of the piers for the new Waterloo Bridge on blue London Clay, heaves of 1 to 3 in. developed during periods of approximately 2 to 4 weeks while excavation was in progress. As the loads from the piers were gradually built up, so the heave ceased and gave way to settlement. If the weight of the building does not exceed the weight of the former overburden then theoretically the settlement will be no greater than the heave and, in the case of clays, the sooner the load from the new construction can be applied, the less will be the heave. The application of this principle of so-called floating or buoyant foundations can be extended with advantage to the case of a structure with one part more heavily loaded than the remainder; if the depth of the basement is increased beneath the heavily loaded part so that the additional weight of excavated material is equal to the additional structural load, differential settlement can be reduced to a minimum. Observations of both heave and settlement should be made during and after construction in order to verify estimates and to provide data for further research.

Buoyant foundations were employed at an oil refinery at Grangemouth, Scotland, where site conditions consist of 80 ft. to over 240 ft. of soft clay overlying boulder clay. In order to reduce settlement to a minimum, a number of foundations were constructed of monoliths, with 12 in. peripheral walls and 6 in. internal walls, dividing them into 10 ft. square cells, which were sunk in the soft clay to a depth such that the weight of soil displaced was equal to the load on the foundations. Floors were cast in the bottom and top of each monolith on completion of sinking. Some settlement has been recorded and this is attributed to heave and disturbance during construction.

A raft is only a large pad footing but it possesses certain characteristics on account of its width and its flexibility. Equations (6) and (7) and (8) and (9), on page 414, reveal that the large width b which obtains for most rafts precludes any possibility of bearing failure on sands, whereas bearing capacity on clay is, for practical purposes, independent of the size of the loaded area. It should be noted, however, that where sands are loose they should be artificially compacted before construction of a raft. The settlement of a uniformly loaded raft on the surface of, or at a shallow depth in, sand is likely to be greater at the edges than at the centre and the raft assumes a dome form but where the raft is founded at depths exceeding about 10 ft. the settlement is likely to be more nearly uniform. Where a footing founded on cohesionless soil exceeds about 10 ft. in width the amount of settlement which occurs under a given pressure is practically independent of the width of the footing, and consequently width can be disregarded when selecting bearing pressure. When a uniformly loaded raft is founded on clay the settlement is greater at the centre than at the edges and the raft assumes a dish-shape but the amount of settlement increases with increase in width of the raft—if the raft is flexible the differential settlement is roughly half the maximum settlement. Since the zone of effective stress influence in the soil beneath a raft covers a greater area and extends to greater depths than the zones of a number of pad footings, the effects of local variations in the compressibility of the soil are mitigated. Coupled with the stiffening effect of the raft and superstructure acting together, this leads to a differential settlement on sand which is likely to be about half that developed with pad footings. Consequently, in order that the superstructure should not show signs of distress, the maximum settlement which can be tolerated with a raft founded on sand is about twice that which could be accepted with pad footings. Differential settlement of a raft on clay can be reduced by making the raft stiff but the possible consequences of providing insufficient stiffness is illustrated at the end of this paper.

A raft can be designed by treating it as a rigid body or by taking its flexibility into account. The rigid-body analysis is commonly employed and consequently uniform or uniformly varying pressure distribution is assumed. The comments which have been made above in respect of the flexibility of continuous footings apply to rafts also. Analysis of flat slab rafts should be based on flat-plate theories where possible in preference to empirical methods and can sometimes be effected by super-position methods, thereby considerably reducing calculations. For exact analyses a strain-energy theory employing

a double Fourier series to represent deflections for rectangular flat slab rafts and Bessel functions for circular, octagonal and hexagonal rafts can be employed. However, in the present state of knowledge such elaborate methods are rarely justified. Rafts constructed of beams and slabs are commonly treated as inverted floors and analysed by statics; undoubtedly such analyses do not yield the truth but design is invariably made conservative.

BEARING PRESSURES UNDER RAFTS

Among the limited amount of research done on rafts, the work of Teng [15] (1949) is of interest. This concerned the distribution of bearing pressure beneath a 180 ft. × 68 ft. raft constructed in 1927 on the pyroclastic clay of Mexico City. The raft is of composite construction, consisting of a 12 in. reinforced concrete mat to which the column loads are applied through a series of longitudinal and transverse 14 ft. 6 in. deep steel trusses. The superstructure is relatively flexible but the stiff raft has been successful in reducing differential settlement to amounts much less than is experienced with many buildings in Mexico City. During the first decade of the life of the raft differential settlement—and hence also bearing pressure distribution—was observed to vary to some extent, although dead and live loads were constant, but differential settlement ceased during the early part of the second decade and it may be inferred that contact pressure had also ceased to change. An important conclusion from this work is that bearing pressure distribution depends largely on variations in the compressibility of the soil and that for design it is desirable to consider several limiting conditions for each structural unit in a raft.

Where the disposition of loading is suitable—for example, uniformly distributed—and where differential settlement is acceptable it may be convenient to adopt a flexible raft so that the load is carried directly by the soil and the bearing pressure is therefore uniformly distributed and equal to the loading intensity. Consequently, bending moments and shearing forces on the raft are theoretically zero, although absolutely uniform bearing pressure distribution cannot be achieved because of local variations in the compressibility of the soil. Terzaghi[16] (1935) has illustrated the application of a flexible raft by reference to a steel tank 100 ft. in diameter and 33 ft. high for containing molasses at Angern, Germany. The tank is founded at a depth of 7 ft. below ground surface in a bed of soft clay, with streaks of fine sand and silt, and at a depth of 13 ft. beneath the tank is a stratum of very stiff clay. The load on the bottom of the tank is 1½ tons per square foot and, since this is a fluid pressure, the distribution of bearing pressure is theoretically uniform provided the foundation is flexible. The form of settlement under this type of loading on clay is dish-shaped. The maximum settlement was estimated to be 4 in. and it was decided to support the tank on a 4 in. concrete slab covered with a layer of bituminous material, since the differential settlement—even if it were equal to the maximum settlement—would not cause distress in a 100 ft. diameter slab of this thickness. Settlement observations confirmed the dish-shaped deformation, although irregularities occurred due to local variations in the compressibility of the soil (Fig. 4 (*b*)). A tank was also constructed at a neighbouring site with similar soil conditions and here it was supported on a reinforced-concrete slab 20 in. thick with 43 in. × 18 in. ribs. In this case, although the load from the tank was uniformly distributed, the settlement tended to be more uniform because of the stiffness of the raft and the bearing pressure distribution was consequently a minimum at the centre and a maximum at the edges (Fig. 3 (*c*)). Bending moments were thus induced in the raft which failed because it was insufficiently strong, the rivets in the bottom of the tank were sheared and the contents flowed out. The additional expenditure in constructing the rigid slab thus led to failure, which could have been averted—once the decision was made to adopt this method of construction—only by making the raft stronger and hence more rigid. The greater rigidity aggravates conditions so that the effects are cumulative although, of course, a raft can be designed to cater for bending moments induced by its rigidity.

CONCLUSIONS

The present position of soil mechanics aspects of foundation design is reasonably satisfactory. Where soil conditions are straightforward or where the structure is not large—for example a domestic house or a small retaining wall—then simple site investigations and tests coupled with elementary soil mechanics theories are sufficient for practical design. On the other hand, considerable practical experience and theoretical knowledge is required where soil conditions beneath projected important structures are complex, and investigations, interpretation and recommendations are best placed in the hands of specialists. The engineer will never be able to escape the fact that soil is the most variable material with which he has to deal and even where a mass of soil is of a uniform type, its physical properties may vary considerably. Apart from general changes in physical properties which may occur across a site, and can be determined by tests and catered for in design, there are innumerable local variations which would entail much work to determine and take into account directly. These local variations can be catered for in the design of important structures by considering the worst limiting conditions or, in suitable cases, by means of a coefficient of variation based on the magnitude and frequency of variations of properties revealed by tests.

It may be argued by some that because of unknown variations in the physical properties of the soil and because of a moderate degree of uncertainty involved in assessing, say, partial fixed end moments in columns and beams, or stresses in reinforced-concrete members, research aimed at deriving estimates of any quantity better than within 20 per cent. is pointless. Nevertheless, as mentioned earlier in this paper, such discrepancies are cumulative, even though statistically they may be partly compensating. Granted that the designer requires straightforward methods of analysis but he needs to know also the limitations of those methods and these can be determined only by research. It is true, of course, that theoretical soil mechanics has outstripped practical applications and therefore the attention of researchers must be directed towards those topics which are most urgently in need of elucidation. The development of appropriate exploratory techniques for different soil conditions, particularly as means of extending the range of a limited number of laboratory tests, and observations for settlement and pressures on completed structures, are two fields of investigation which need exploiting and should yield rich returns.

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DEVELOPING TIMBER FOR INDUSTRY

T.D.A. Laboratory near High Wycombe

During the next three years timber research is to be greatly expanded. As the first step, the Timber Development Association will shortly transfer its present scientific and technical activities from London headquarters, 21 Collegehill, E.C.4, to more adequate industrial premises at Tylers Green, near High Wycombe. This decision is the outcome of an announcement earlier this year that the Department of Scientific and Industrial Research is willing to make an annual grant to the Association towards the cost of research calculated to raise the standard of wood usage in this country.

The T.D.A. research programme will supplement the fundamental studies carried out at the Forest Products Research Laboratory (D.S.I.R.), at Princes Risborough. Investigations will be concerned less with wood as a material than with its uses in selected fields of industry, with special regard to design, production and processing. Basic knowledge built up at Princes Risborough will be utilised to the full in applied research and pilot developments aimed at assisting designers, builders, industry and wood consumers generally.

In building, structural engineering and indeed in many fields where timber has an important part to play, industrial practice still lags behind experimental achievement. Work now planned for the Tylers Green centre should go a long way towards bridging the gap between laboratory and workshop.

The need for technical development is nowhere more apparent than in timber construction. Improved grading, advances in glue technology and timber laminating as well as the systematic re-estimation of timber's qualities from an engineering standpoint have extended the horizon in every branch of construction.

Research into glued lamination will occupy a leading position on the new laboratory's schedule of projects. Emphasis will be placed on the economic aspects of "gluelam" production. Standardisation and mass production of components, already a reality in the United States and Canada, are only now being considered in Britain, but it is hoped that as a result of studies undertaken at Tylers Green the way will be opened for parallel developments over here, and that eventually the designer will have at his disposal a full range of gluelam components in standard lengths, sizes and strengths, which can be incorporated in structures with the same ease and guarantee of service as fabricated steel sections. Early attention will, therefore, be given to the design and testing of components at Tylers Green and, in collaboration with timber firms, laminating techniques will be closely studied with a view to simplifying and cheapening factory methods.

The new laboratory accommodation secured by T.D.A. affords excellent facilities for this and other pressing research projects. It includes a large test-shed, laboratories and a workshop to be equipped with standard woodworking machinery and tools for making experimental apparatus. Prominent among the main installations will be a mechanical test bed, which can be set up to subject timber girders and trusses of up to 100 ft. in length to the most rigorous loading stresses. Land adjacent to the laboratory premises will be used as an open proving ground for structures, fencing and timbers used for the exterior cladding of houses. Here the architect and engineer will be able to inspect full-scale structures of advanced design, some of them undergoing test.

Arrangements for moving the Association's main technical departments to Tylers Green are already in hand and it is expected that the laboratory will have settled down to its immediate programme well before the winter. The Association's technical advisory service will continue to be conducted from the London headquarters.

LOS PEARES HYDRO-ELECTRIC POWER STATION

BRITISH PLANT INSTALLED IN SPAIN

The Los Peares station, which was officially opened by General Franco, Head of the Spanish State, on Saturday, September 3, is part of a scheme for developing the hydro-electric resources of Galicia, which is being undertaken by Fuerzas Eléctricas del Noroeste, S.A. (Fenosa). When this company was formed in 1943, most of the large towns in the province had generating stations which, however, merely supplied local networks. In fact, the only area where the demand was sufficient to warrant high-tension transmission was that between Vigo, Corunna and Ferrol. As will be seen from the map reproduced in Fig. 1 this was supplied from a hydro-electric station at Tambre (22·5 MVA) through 66 kV lines.

The company therefore obtained powers to develop the River Limia at Las Conchas, where a 31 MVA station has been built, and to connect this by 132 kV lines to a thermal station at Ponferrada (50 MVA) and to the El Troncal sub-station at Vigo. Plans were also made to construct water power stations on the River Mino at Los Peares (187·2 MVA) and at Belesar (225 MVA). These are connected by 132 kV lines with a thermal station at Puentes de Garcia Rodriguez (40 MVA) and thence to Ferrol. At a later date it is proposed to erect stations at Puertomarin (3·6 MVA), Castrelo (86 MVA) and Frieira (20 MVA) on the River Miño at Salas (80 MVA) on the river of that name and at Aceredo (39 MVA) and La Raya (8 MVA) on the River Limia. These stations are not shown on the map.

Turning to the Los Peares station, a gravity dam rising 295 ft. above the normal river bed and with a curvature of about 1,000 ft. radius has been constructed between steep banks which rise almost 45 ft. As the rock is sound granite it was only necessary to excavate to a depth of about 12 ft. to reach a solid foundation and, although pressure grouting was employed, it was found that very little grout could be injected.

The flow varies from 140,000 cub. ft. per second in the winter to only 530 cub. ft. in the summer and to pass the former amount a width of 225 ft. was required between the outer columns of the spillway at the top of the dam. The water had also to enter the spillway parallel to its sides. Moreover, owing to the narrowness of the river the stilling basin could not be made more than 150 ft. wide without considerable excavation. The crest of the spillway is at the 610 ft. level, and above it storing gates retain the water to a maximum level of 646 ft. The length of the stilling basin has been reduced by placing a row of blocks on the bracket at the base of the dam and the water passing between these is thrown back by baffles. The power station is built alongside the dam partly in the hillside, so that considerable excavation was necessary both for its construction and for the entrance tunnel, the general arrangement being shown in the plan, Fig. 2. The completed dam and power station are illustrated in Fig. 3.

CONSTRUCTIONAL METHODS

As regards construction the local granite was used as the aggregate for the concrete and was reduced to workable sizes in crushing plant with a capacity of 45,000 cubic feet a day. The cement was manufactured in a local plant with a capacity of 200 tons a day, to which clinker and other material was brought by rail and then carried to the site by a transporter some two miles long. The concrete-mixing plant was fed with cement by wagons of known tare and with aggregate of the required size by a belt, the output being over 2,000 tons per day.

Two methods were used for placing the concrete. Immediately under the mixing plant it was run in pipes to each lift by gravity, the final distribution being made by tubs, where necessary. For the more distant parts of the dam it was carried in hoppers by an aerial ropeway, discharged into the funnel-shaped tops of two towers and placed by gravity, using flexible pipes.

Two 10 ft. diameter pipes are provided in the left-hand bank for use should it be necessary to drain the site. There are also drainage pits and inspection tunnels at four levels inside the dam. To seal the expansion joints in the structure a wedge-shaped cavity was formed for the full height of the dam at the centre line of each joint and close to the upstream face. A vertical concrete pillar, the same shape as the cavity, was built to the full height of the dam with its base solidly anchored. The joints and the area between the column and the dam were then filled with sealing compound, the pressure of water through which deflects the column into the wedge, thus ensuring water-tightness.

PENSTOCK ARRANGEMENT

Each of the three turbines described below is fed through a 13ft. penstock, which is built into the face of the dam, the intakes being protected by two trash racks, and the opening being closed by a gate, which is operated from the power station. The main turbine valve is at the base of each penstock and is operated by an hydraulic servo-motor. This valve is 13 ft. in diameter and is designed to withstand an unbalanced pressure of 305 ft. of water. An electrically-operated by-pass valve is provided to flood the spiral casing, where the water is retained by the guide vanes, and to equalise the pressure before opening the valve. Operation is effected from the turbine control panel, the condition of the valve being indicated on a mimic diagram. When the main valve is closed the by-pass valve is also automatically returned to its " off " position.

TURBINE DESIGN

The turbines for which Messrs. Boving and Company, Limited, 56 Kingsway, London, W.C.2, were the contractors are designed for an output of 72,800 h.p. at a maximum head of 305 ft., the speed being 214 r.p.m. The spiral casings of these machines, one of which being assembled on its foundations is illustrated in Fig. 4, are built up of steel plate fabricated in sections and welded on site. The stayring, to the outer periphery of which the casing was subsequently welded, is 18 ft. in diameter and consists of two rings of steel plate separated by vertical vanes. The steel guide vanes are fitted with rubber strips to ensure water-tightness and are connected by levers and links to the regulating rings, which are controlled by an actuator through a valve and servo-motor.

The cast-steel runners are 8 ft. 6 in. in diameter and consist of 18 blades, which were shaped on a profiling machine and checked to a jig before assembly with the band and hub, which were pre-machined. The band and outlet edges of the blades were welded with stainless steel as a protection against cavitation. The surfaces of the blades were then ground to a fine finish

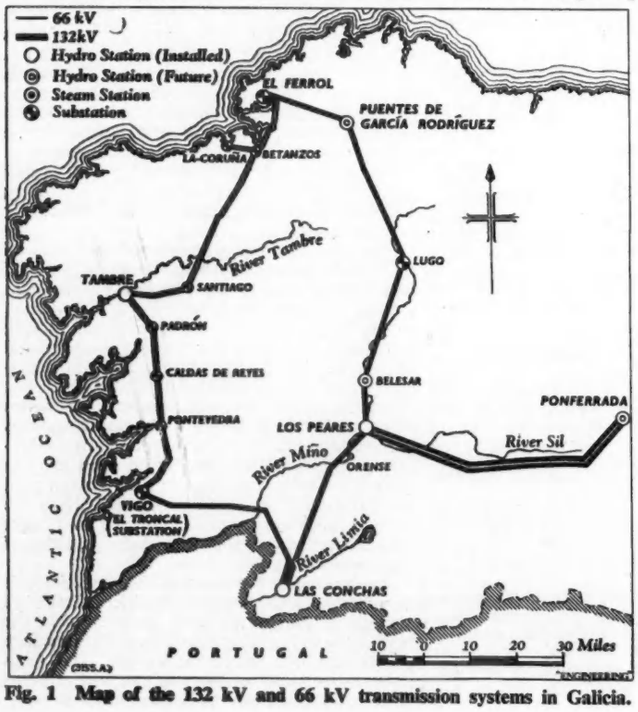


Fig. 1 Map of the 132 kV and 66 kV transmission systems in Galicia.

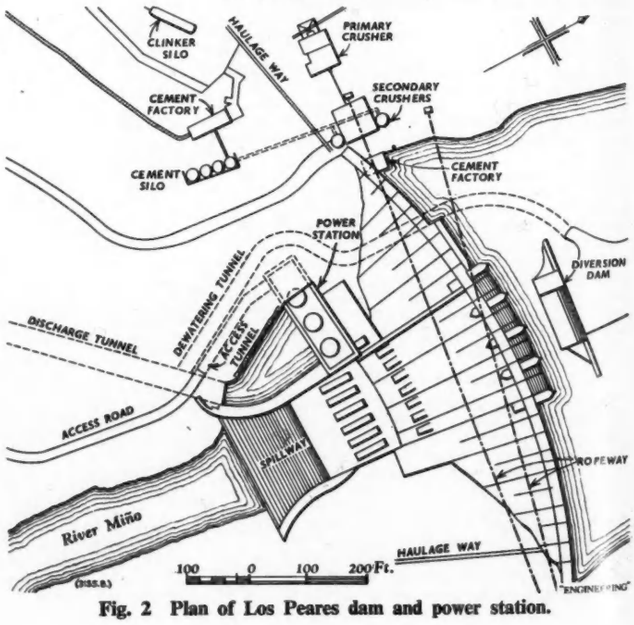


Fig. 2 Plan of Los Peares dam and power station.

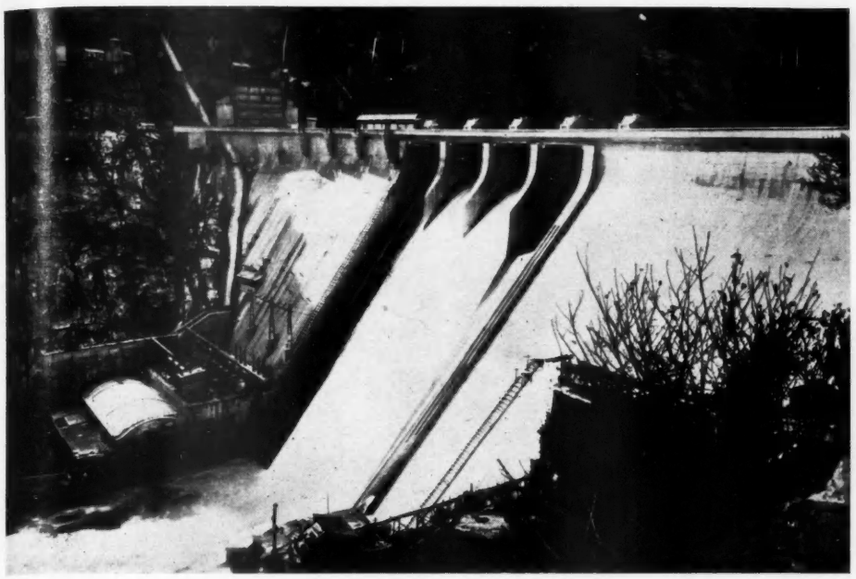


Fig. 3. The completed dam with the power station in the left foreground and the switching station above.

and the runner band and hub were finally machined and fitted with renewable stainless-steel wearing rings.

SPEED CONTROL

The guide bearing, which is of the conventional type, is mounted on the cover of the stayring. The governor is of the pendulum pattern and is driven by a synchronous motor, which is supplied from a governor generator on the main shaft. The shaft, on which the pendulum is mounted, acts as the piston of a pilot valve and its movement admits oil to a regulating valve. This valve, in turn, regulates the oil supply to a servo-motor in the actuator. This servo-motor controls the position of the main regulating valve and by rotating the regulating ring adjusts the position of the guide vanes according to requirements.

Control of the speed when running light or in parallel with other machines is effected by a "speeder" motor, which over-rides the movement of the pendulum and allows the operator to control the guide vanes directly. There is also a "load limiter" which prevents the governor regulating valve from opening beyond a certain point should the water conditions require it. Interlocks ensure that the main valve cannot be operated unless the guide vanes are locked in the closed position.

ALTERNATOR CONSTRUCTION

The alternators, which like the main and distribution transformers, main and auxiliary switchgear, control and relay equipment and power station auxiliaries, were supplied by the British Thomson-Houston Company, Limited, Rugby, are each rated at 62,400 kVA and are designed to generate three-phase current at 11 kV and 50 cycles. One of these machines, assembled for test in the Rugby works, is illustrated in Fig. 6. The floor of the machine room, which is shown in Fig. 5, is intermediate in level between that of the turbines and the loading bay, thus reducing the amount of excavation required and the length of the alternator shaft. It also gives ample head room and simplifies the cooling system, which comprises air/water heat exchangers arranged in the corners of a square pit. This pit is divided into hot and cold compartments through which air is circulated by a fan on the rotor.

The rotor itself is carried in guide bearings at the top and bottom of the alternator as well as in the turbine guide bearing, while the vertical load due to its weight and that of the turbine runner, as well as the hydraulic thrust, is carried by a bearing on the top of the housing, the total thrust on which is about 400 tons. The upper guide bearing and the thrust bearing are combined in one housing and are supported on the top of the stator by eight radial arms. The bottom bearing is carried in a housing directly under the rotor. All the alternator bearings are of the Michell type.

The 28 rotor poles, each of which is 70 in. long, are carried on four rim sections. The coils are fabricated from copper strip the joints being interlocked by a jig-saw construction. The winding is insulated from the body of the pole by mica, while the inter-turn insulation is asbestos. Cooling ducts which coincide with the rotor rim sections are provided and straps ensure that the winding does not distort at overspeed. These straps are arranged so that any pole can be withdrawn without removing the rotor from the stator. The rotor rim sections are keyed to a fabricated spider, which is bolted to two flanges on the shaft, as is the coupling connecting to the turbine.

STATOR DESIGN

The stator is built up of welded steel plates which are reinforced by bars through the length of the frame under each bracket arm. It weighs 96 tons and is 24 ft. in diameter by over 8 ft. high. The core was manufactured from insulated laminations which are held in position by dovetail keybars. These bars are welded to the frame, great care being taken to ensure concentricity. The winding is of the double-layer wave-connected type and is insulated over the slot position by a mica tube. This tube is protected by asbestos tape, which is treated with semi-conducting paint so that it acts as a corona shield. The end windings are wrapped with mica tape, which is secured by glass tape. Each bar consists of a number of separate conductors which are insulated from each other in the slot portion, but are short-circuited at the joints. To limit the induced voltage between these conductors—due to the unequal flux distribution across the slot—they are transferred in the stator core so that they occupy every possible position in the bar.

As the stator had to be divided into quarters for shipment it was dispatched without the windings. Each bar was sealed in a tube of polythene and placed in a box with supports to ensure that the mica tube should not be cracked by an accident during the journey.

Compressed-air brakes are mounted on the bottom bracket of the stator and operate against a plate on the lower rotor rim. The braking surface is not rigidly bolted to the rim so that radial expansion is possible. The main and pilot exciters are mounted above the thrust bearing and are designed for use in conjunction with a normally-inactive voltage regulator, field-forcing contactors and a motor-operated rheostat.

TRANSFORMERS

The main transformers consist of a bank of three 20·5-MVA single-phase units which are solidly connected to the alternators and step up the voltage to 132 kV, off-load tapping switches, arranged for external operation, being provided to give 145·5, 138·578 and 131·815 kV. They are installed on a platform at roof level between the station and the dam, as can be seen in Fig. 4, and are connected to the switching station by overhead lines. As access to the transformer platform is only possible by a lift it was necessary to employ single-phase units and the weight and size were still further reduced by employing water cooling for the oil.

Two three-phase transformers, one with an output of 6 MVA and the other with a capacity of 4 MVA, are installed in the switching station and step down the voltage from 132 kV to 20 kV for local distribution. There is also a 1,000-kVA, 11,000/380-volt transformer associated with each generating group to provide auxiliary supplies and two 750-kVA transformers which are connected to the 20-kV bus-bars and are used when the station is not in operation. Finally, there is a 140-kVA Diesel-alternator set, which acts as an additional stand-by. All

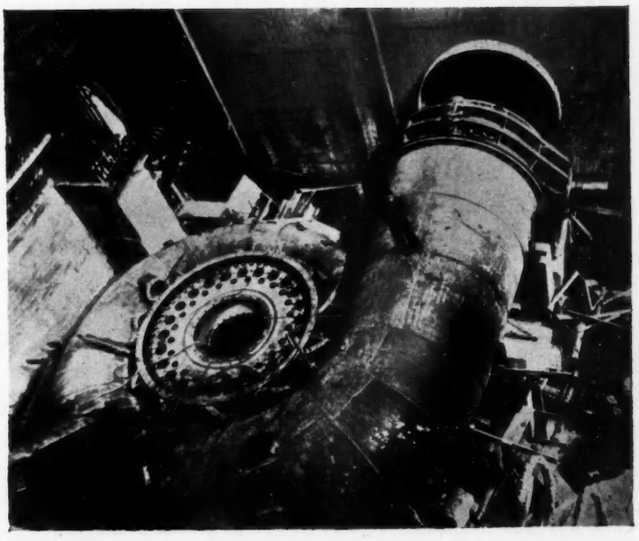


Fig. 4 Spiral casing of 72,800 h.p. turbine assembled on its foundations.

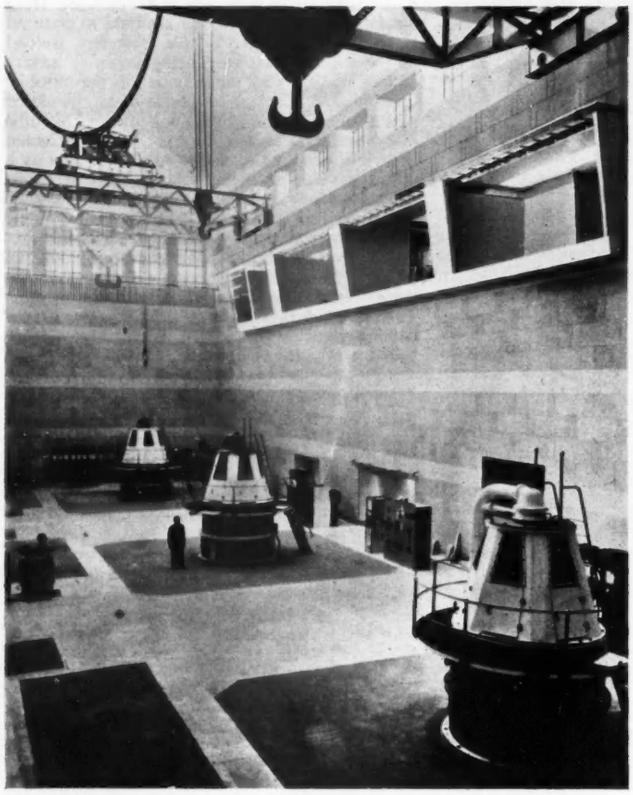


Fig. 5 Machine room in Los Peares power station, showing the three 72,800 horse-power turbines.

Fig. 6 62·4 MVA alternator on test in Rugby works. The stators had to be divided into quarters for shipment.

the transformers were manufactured by the British Thomson-Houston Company.

SWITCHING STATION

Owing to the limited space available and the number of outgoing 132-kV lines it was found that a separate switching station, controlled from the power station, would be necessary. The choice of site was limited, owing to the desirability of keeping the length of the connecting cables to a minimum; and it was eventually decided to utilise a disused quarry at a distance of 2,000 ft. from the control room. This decision in turn imposed limitations with regard to plant layout, since the side of the hill was so steep that the cost of providing a platform wider than 130 ft. could not be justified, although almost unlimited length was available. An illustration of the switching station as now constructed appears in Fig. 7.

The site was laid out to accommodate five outgoing feeders, two local supply transformers and a bus coupler, in addition to the three alternator circuit-breakers. The local transformers step down the voltage to 20 kV, and are connected to a system consisting of two incoming feeders, four outgoing lines and a bus coupler. The two voltage groups are separated in the switching station by a house in which relays and auxiliaries are installed.

An overhead layout has been adopted, the duplicate 132-kV busbars running the whole length of the station with the bus coupler at one end. The isolators, insulators, potential transformers and surge diverters are supported on reinforced concrete structures. All the lines take off from strain towers on the hillside above the site.

Both the 132-kV and 20-kV circuit-breakers are of the bulk-oil type. The former are of the British Thomson-Houston Company's Shuntarc pattern and are rated at 2,500 MVA. Single-phase auto-reclosure is provided on the circuit-breakers controlling the feeders, there being three separate operating mechanisms. The circuit-breakers without automatic re-closure, however, have a common operating mechanism for all three phases. A total break time of three cycles can be achieved at any duty within their range. The 20-kV circuit-breakers are of similar construction but do not incorporate shunting resistors and all three phases are in one tank.

EARTHING ARRANGEMENTS

The isolating and earthing switches are mounted on gantries adjacent to the busbars or strain towers and are operated from ground level. Due to the prevalence of lightning in the area, a screen of earth wires is provided over the switching station and the lines to the power station. An earth ring and four earth plates are also buried round the site and a similar earth ring is laid in the power station. A heavy copper conductor is run beneath the headwaters of the reservoir to provide a bond between the two systems.

CONTROL ROOM

All the circuits, including those for the power station auxiliaries and for load dispatching, are controlled from a room in the power station. The equipment installed for this purpose includes a miniature type control board for each voltage, which consists in each case of a series of cubicles 6 ft. 6 in. high and of standard width. A mimic diagram, the colour of which indicates the voltage, is painted on the face of the panels. The alarms and instruments associated with each circuit are located at their particular section of the panel, while the station instruments are concentrated on the centre panel. The usual visual and audible alarm indications are provided by telephone-type equipment.

The load control of each alternator is centred on a desk facing the 132-kV board. Associated with the 380-volt board is a section on which the head and tail-water levels, the readings of the position indicators and the controls for the spillway gates are shown. Included on the 20-kV panel is the control for a 11-kV test circuit-breaker. This is installed to protect the alternator when tests on the turbine are being carried out and the output is being dissipated by electrodes immersed in the stilling basin.

The auxiliary transformers mentioned above are also controlled from the control room, as are the various direct-current circuits and battery-charging equipment.

The outgoing feeders are protected by high-speed distance impedance protection backed by over-current protection, and over-current protection is provided on the busbars, and circulating current, earth fault, over-current and over-voltage protection for the alternators.

Fig. 7 The switching station.

ENGINEERING, MARINE AND WELDING EXHIBITION

AND THE FOUNDRY TRADES EXHIBITION OLYMPIA, LONDON SEPTEMBER 1—15

Sixth Article

This article, the sixth, brings to an end our descriptions of some of the items at the Engineering and Marine exhibition which closed on September 15. During the time it was open, the 500 stands were visited by people from over 60 countries, the Netherlands and India being particularly well represented. There were also several visitors from the U.S.S.R., who studied the products very keenly. As far as can be ascertained, most exhibitors decided that the display was well worth while.

FLUID-COUPLING REVERSE GEAR

The Fluidrive Engineering Company, Limited, Weston-road, Isleworth, Middlesex, were showing several types of Vulcan-Sinclair fluid couplings, including two of recent design. Others were examples of high-power, high-speed variable speed drives and sectioned examples of traction and scoop-control couplings. One of the new designs was a Dual Fluidrive with two-speed S.S.S. gear intended for a 500 h.p. Diesel locomotive with a constant-horse-power supercharged engine, and the other was a Dual unit for a winch drive or other industrial purpose. The latter is illustrated in Fig 68, below.

The drive to this coupling is from a 40 h.p. squirrel-cage motor running at constant speed. Two couplings are used, one driving direct on to the output shaft and the other through an idler-train to reverse the rotation. Control of the oil in the working circuits is by means of a rack-operated transfer scoop, the transfer taking place very rapidly. At the exhibition, the gear unit had a fairly heavy flywheel mounted on the output shaft to show how reversal takes place. The transfer scoop is an opened ended tube which is placed at an angle to the driving shaft, one end being in each coupling. In the unit on show, operation was by a lever, but the illustration shows a rack and pinion mechanism which is also available. The length of the scoop tube is such that in the neutral position it lies midway between the two couplings and no transfer of oil occurs. Operating the mechanism projects the scoop into one of the couplings, from which it then transfers the oil to the other. Thus one coupling ceases to drive and the other takes over, reversing the direction of the output shaft. In the case of the dual-speed unit, two seperate scoops are used, mechanically linked so that when one is projected the other is withdrawn. The gear train does not contain an idler, but the drive is transmitted from shaft and sleeve by two pairs of gears. The standard speed ratio from fast to slow is 2 to 1. In both units the change, whether from fast to slow or forward to reverse, is extremly rapid and absolutely smooth.

NON-FERROUS METAL ALLOYS

As could be anticipated, titanium and titanium-alloy strip, sheet, tubes, wire, rods, sections, forging stock and ingots were on view on the stand of Imperial Chemical Industries, Limited, Metals Division, Witton, Birmingham. Tubes and plates in Kunifer (copper-nickel-iron), Alumbro (copper-zinc, aluminium), Resisco (copper, aluminium, nickel), Admiralty and 70 : 30 brass for condensers, coolers and other equipment for land and marine steam plant and for oil and sugar-refinery installations were also shown. Among the aluminium-alloy exhibits were Kynal extrusions, sheet and plate for land and marine transport applications, and Kynal aluminium busbar and jointing compound.

High-nickel alloys introduced to meet industrial requirements for materials resistant to corrosion and high temperatures, were to be seen on the stand of Henry Wiggin and Company, Limited, Wiggin-street, Birmingham, 16. Among the exhibits were carburising boxes, a Diesel-engine turbo-blower, exhaust valves for high performance internal-combustion engines, examples of pyrometer sheathing, cores and dies used in the casting of aluminium-bronze components, and of Diesel-engine pre-combustion chambers. Recent applications of the Monel, Inconel, Corronel and Nimonic series of alloys were shown in colour photographs.

Many examples of the use of the heat, corrosion and abrasion-resistant hard facing alloys were exhibited on the stand of Deloro Stellite, Limited, Highlands-road, Shirley, Birmingham. Of particular interest were examples of a recent development, the tipping of band-saw teeth with Stellite. In addition to a longer working period between regrindings the effective life of a tipped band-saw is considerably increased. Moreover, when finally worn, the saw may be re-tipped and returned to service.

To demonstrate the ease of application of hard-facing alloys, by any conventional welding process, on tools, milling blades, centres, work-rests, drills, Diesel-engine valves, rockers and other components, there was in operation a complete oxy-acetylene welding bench and an arc-welding booth, the latter being a new feature.

In addition to copper and copper-alloys in the form of wire, strip, rings and bars for the electrical industry, Thomas Bolton and Sons, Limited, Mersey Copper Works, Widnes, Lancashire, were showing plate, bars, tubes and extruded and drawn sections for use in marine engineering, including a 20 ft. length of 3½ in. diameter phosphor bronze bar which is used for propeller shafts. Copper service tubes for installation in dwelling houses, copper printing rollers for the textile and other industries, and cadmium copper and various special-alloy electrodes for use in spot and seam welding, were also on view.

PROFILE CUTTING MACHINES

The British Oxygen Company, Limited, Bridgewater House, Cleveland-row, London, S.W.1, exhibited two new profile cutting machines, the "Bison" and the "Beagle," and the new 21E Argonaut welding unit, besides other items of welding equipment.

The Beagle is a lightweight, transportable oxygen cutting machine which can make one-off profile cuts in mild steel up to 2 in. thick. It can describe both bevels and square-edge cuts in any direction within the cutting area. Light alloys have been used extensively in its design and its weight is 125 lb. The Beagle is in effect a pantograph and consists basically of two slides set at right angles to each other. The transverse slide is mounted on the lateral slide and travels both across and along it, and has at its extremities the drive motor and cutter respectively. The cutter, which is designed to use standard Cutogen one-piece cutting nozzles, has a swivelling arrangement which enables the machine to main-

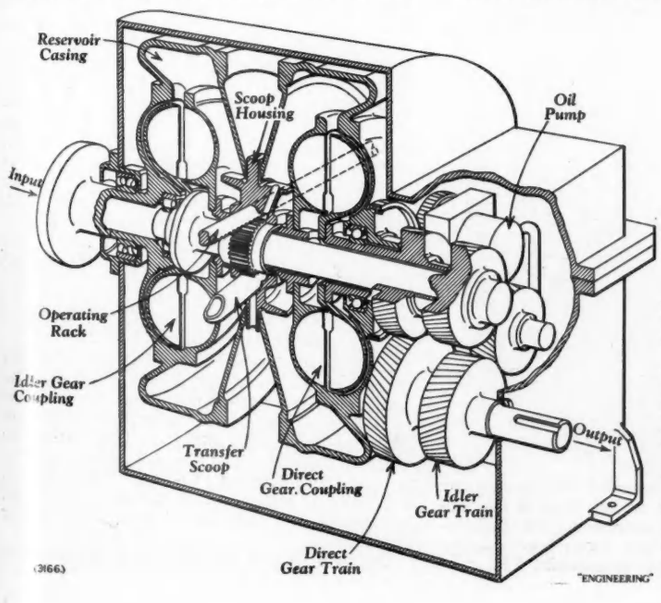


Fig. 68 By means of a transfer scoop which can be projected into either coupling, causing the other to take up the drive, the direction of the output shaft is reversed. Fluidrive Engineering Co., Ltd.

Exhibits Described

Fluid Coupling Reverse Gear
Fluidrive Engineering Co., Ltd.

Non-Ferrous Metal Alloys
I.C.I., Ltd., Metals Division
Henry Wiggin and Co., Ltd.
Deloro Stellite, Ltd.
Thomas Bolton and Sons, Ltd.

Profile Cutting Machines
Argon-Shielded Welding Equipment
British Oxygen Co., Ltd.

Trolley-Mounted Engine Indicator
Southern Instruments, Ltd.

Magnetic Rotary Seal *Stothert and Pitt, Ltd.*

Air Cooled Diesel Engine *J. and H. McLaren, Ltd.*

Gasworks Motor *Newman Industries, Ltd.*

Explosion and Fire Protection System
Graviner Manufacturing Co., Ltd.

Split Bearings *Cooper Roller Bearings Co., Ltd.*

Self Regulating Alternator
The Electric Construction Co., Ltd.

"Universal" Hydraulic Valves
Keelavite Rotary Pumps and Motors, Ltd.

Compressors and Pneumatic Tools
Broom and Wade, Ltd.

Diesel-Engine Driven Welder
Lincoln Electric Co., Ltd.

E.B. Weld Insert Process
Economical Welding Equipment *Rockweld, Ltd.*

Remote Water Level Indicator *Hopkinsons, Ltd.*

Rust-Proofing Processes and their Automatic Application *Walterisation Co., Ltd.*

Spot Welders *The A.R.O. Machinery Co., Ltd.*

Supercharged Diesel Engine with 625 kVA Alternator *Harland and Wolff, Ltd.*

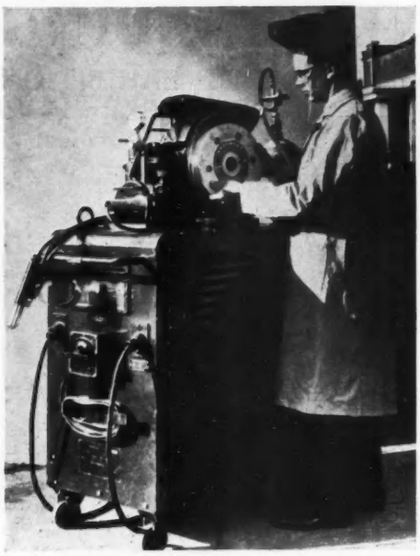


Fig. 69 Type 21E Argonaut welding equipment. The water-cooled hand gear is shown hanging over the front of the CDR 425 power unit; a reel of filler wire is being fitted into the carriage unit. British Oxygen Co., Ltd.

tain a constant bevel in curves through the most intricate profile cut. For ordinary vertical cutting the racking arrangement controlling the bevelling device can be disengaged.

The Beagle is powered by an electric motor driving a hand-steered knurled tracing wheel, which is guided over a drawing made on stout card or paper; a sheet of Perspex should cover the paper and hold it in position. The machine is extensible in increments of 6 ft. by fitting additional sections to the longitudinal slide. By this means longitudinal cuts of any length can be made, but the maximum width remains 2 ft. 6 in.

The Bison is a profile cutting machine operating on the cross carriage principle, and is supplied in two sizes; the maximum width of cut is 42 in. for size 1 and 84 in. for size 2, and the standard length of cut is 42 in. for size 1 and 84 in. for size 2. Any further desired length can be obtained by adding the appropriate number of track extensions, which are available for both machines in units of 42 in. length.

The Bison is suitable for one-off or repetition work, and a variety of drives which are described below can be supplied for use with steel templates, wood or aluminium templates, or drawings. The standard machine is fitted with one cutter, but two or three cutters can be mounted for multiple cutting of identical shapes simultaneously. All the electrical controls and the speed indicator are located together in a control box which slides on the floating boom so making it accessible from either the tracing head or cutter positions. All gases may be shut off from the tracing head or from the cutter. The cutters are the MC 12 type, suitable for use with acetylene, propane, or coal-gas.

There are three methods of driving the Bison. First, magnet head; this is for automatic operation on repetition work and consists of a magnetic roller which follows the outline of ¼ in. mild-steel templates. Second, spindle head; the spindle is driven to ensure consistency of cut, but is hand guided round wood or soft metal templates which may be quickly made for use where only a few parts off are required. Third, tracing head; this may be used for working direct from a drawing when only one or two parts off are needed, and consists of a knurled wheel which is driven but which must be guided over the drawing. An optical attachment is available for use with the tracing head which projects a cross of light on to the drawing so that the lines may be accurately traced.

ARGON-SHIELDED WELDING EQUIPMENT

The type 21E Argonaut welding equipment, illustrated in Fig. 69, is a manual inert gas shielded consumable electrode arc welding equipment capable of continuous working with current up to 500 amperes and intermittent operation up to a maximum of 600 amperes. It is suitable for welding heavy sections of aluminium, steel, and copper, which normally require higher current ratings than ordinary light alloy welding.

The hand gun, which can be seen hanging over the front of the power unit, is water cooled, light, and fully insulated. It directs the filler metal to the weld and also carries the shrouding argon gas. It has an inbuilt trigger switch for control of the welding current, shielding gas, water supply, and wire feed. An inching button is provided at the base of the butt for feeding the wire prior to welding.

The carriage unit, shown on top of the power unit, embodies a magazine which carries the reel of filler wire, a wire feed motor with an inbuilt electro-mechanical governor for feeding wire to the gun, and a control box containing the electrical controls for operating and synchronising shielding gas and cooling water. Power for the equipment is supplied by the CDR 600 or CDR 425 power unit, having maximum outputs of, respectively, 600 and 425 amperes direct current. The CDR 425 is shown in the illustration, but the 600 is recommended for welding mild steel, stainless steel, copper and heavy sections in light alloy.

TROLLEY-MOUNTED ENGINE INDICATOR

Equipment for indicating pressures in any internal combustion engine or compressor was shown on the stand of Southern Instruments, Limited, Frimley-road, Camberley, Surrey. The complete equipment, shown in Fig. 70 is built in rack and panel form and is mounted on a trolley. The 6 in. cathode-ray tube is on a hinged mounting and can be swung out for easy viewing. It can also be positioned so that still, continuous-feed, or drum camera records of the display can be made on 70 mm. film or paper. The camera is equipped for daylight loading so that the photographic record can be removed for developing and subsequent analysis without interfering with the operation of the equipment.

The pressures are initially converted into electrical signals by means of variable-capacitance or variable-resistance pressure gauges tapped into

Fig. 70 This trolley-mounted engine-indicator equipment can be used in any type of internal-combustion engine or compressor. The cathode-ray tube swings out to give a convenient viewing position. Southern Instruments, Ltd.

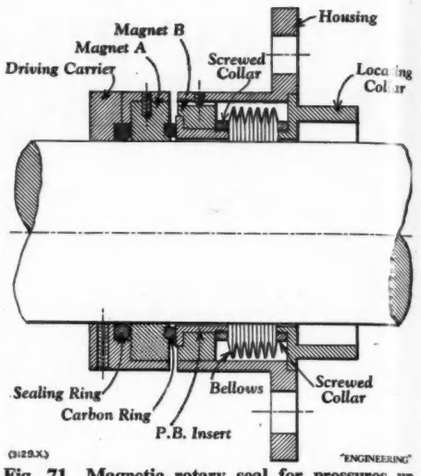


Fig. 71 Magnetic rotary seal for pressures up to 250 lb. per sq. in. Stothert & Pitt, Ltd.

the cylinder head, manifolds or pipework. These signals are then fed into suitable amplifiers to provide a display on the cathode-ray tube. The apparatus responds to sustained as well as fluctuating pressures. This enables the diagrams to be calibrated by the application of known steady pressures from a dead-weight tester.

As nearly all phenomena on an engine are related to the crank revolution, provision has been made to mark the diagram with a scale representing crank-angle degrees.

The range of pick-ups includes variable-capacitance types having a pressure range of a few inches of water up to 10,000 lb. per square inch, variable-resistance pick-ups to 35 tons per square inch and pick-ups for injector-needle lift, fuel-line pressure, vibration, etc.

MAGNETIC ROTARY SEAL

Stothert and Pitt, Limited, Bath, were displaying a wide range of their products, including a cargo winch driven by an alternating-current motor fitted with Laurence Scott's "Revcon" control. By using this, very fine control of speed is obtainable without cumbersome switchgear. Also on the stand were examples of the firm's pumps for many purposes and, among them, some fitted with a magnetic oil seal.

This seal is the product of the J. C. Rotary Magnetic Seal Company, Limited, London-road West, Batheaston, Bath. It can be fitted without altering the design of the pump as the gland plate is made to suit the existing fixings. A sectional drawing is shown in Fig. 71. The actual seal is formed by a carbon ring which runs on a phosphor bronze face and is held against it by two ring magnets. Sealing bellows allow the ring to take up its alignment and compensate for any wear that may occur. One magnet is held in a carrier which is sealed to the shaft and revolves with it while the other is carried on the gland plate. The seal can withstand pumping pressures up to 250 lb. per square inch and a vacuum down to 26 inches of mercury. The present range of sizes is for shafts from 1 in. to 7 in. in diameter. Unlike spring-loaded seals, the sealing pressure increases as wear occurs. These seals have found approval in the oil industry because neither heat nor static electricity is generated.

AIR-COOLED DIESEL ENGINE WITH BRITISH-MADE CLUTCH

Among the engines shown on the stand of J. and H. McLaren Limited, Airedale Works, Leeds, 10, was an L.E.6 water-cooled Diesel engine, one of the new range announced recently and described in ENGINEERING on page 248 *ante* (issue of August 19). This six-cylinder engine, in the supercharged version, can produce 240 h.p. at 1,800 r.p.m. It has been developed particularly for contractors' plant and similar applications.

The B2M marine propulsion unit also on show

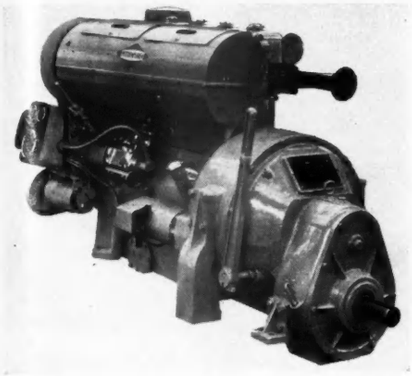


Fig. 72 The Petter/McLaren PD4 air-cooled Diesel engine was shown fitted with an Anderton clutch/reduction unit. J. and H. McLaren Ltd.

develops 18 s.h.p. at 1,500 r.p.m. and is one of a range having two, three or four cylinders, designed for inshore work. The one shown was fitted with a Parsons 2 : 1 reverse/reduction gearbox. Another marine unit was the M8, developing 180 s.h.p. at 1,200 r.p.m., which was shown with a Hindmarsh oil-operated gearbox giving a 3 : 1 reverse/reduction. This engine is claimed to have a full-load fuel consumption of 0·36 lb. per b.h.p. per hour and has closed circuit cooling.

Three engines were shown from the PD and PDV range, of air-cooled engines. The PDV8, rated at 96 b.h.p. at 1,800 r.p.m., which is believed to be the largest air-cooled Diesel engine made in Britain, was fitted with a Torcon torque-converter unit, giving a torque multiplication of 3 : 1. The PDV6 was shown driving a dual-frequency Brush Amplidex alternator with integral control gear, which generates at 400/440 volts producing 47·5 kW at 60 cycles—or 39·5 kW at 50 cycles. At either frequency the voltage is maintained constant within $\pm 2\frac{1}{2}$ per cent.

The third engine in the series, the PD4 (which has four cylinders in line as against the V-formation of the other two) develops 48 b.h.p. at 1,800 r.p.m. It is illustrated in Fig. 72. The engine is intended for industrial purposes and has been fitted with a clutch/reduction gear unit made by W. R. Anderton and Company, Limited, Railway Iron Works, Castleton, Rochdale. This is believed to be the first British-made clutch for use in this type of work, and can take the place of the Rockford unit. Two sizes are made, 9 in. and 11 in. These will transmit a torque of 236 lb.-ft. and 342 lb.-ft. respectively with maximum speeds of 2,800 and 2,500 r.p.m. Either can be fitted for 2 : 1 or 3 : 1 reduction. When fitted with the clutch unit, the engine is particularly suitable for applications requiring a belt drive, and the pulley diameters and belt speeds can be kept within reasonable limits.

GASWORKS MOTOR

The motor illustrated in Fig. 73 is one of a number which were being displayed on the stand of Newman Industries, Limited, Yate, Bristol. It has been designed to meet the requirements of gasworks and ordnance-factory engineers and is dust-proof, weather-proof and hose-proof. It is being manufactured for outputs between $\frac{1}{2}$ and 25 h.p. and is constructed to British standard dimensions with a few simple additions and modifications.

As regards construction, the only difference in external arrangements is that the terminal box is flameproof with wide flanges, the mounting posts being embedded in separate synthetic resin-bonded moulded insulators. There is, therefore, an effective seal between the box and the inside of the motor, thus preventing the entry of dust or water. The box can be arranged for direct conduit entry or can be equipped with a sealing chamber and armoured glands. In both cases either wide flanges or extra long threads can be provided.

The bearings are doubly protected by "wiping" type seals which are fitted in addition to the ordinary closures. Stud-type bearing caps are employed and a locknut is used to secure the keyed fan to the shaft in place of the more usual Circlip. As a final precaution against dust the end bracket joints are coated with a sealing compound during assembly.

The end windings are given a coat of varnish which is highly resistant to moisture and dust, in addition to the normal impregnation, while to ensure that moisture and dust cannot creep in along the securing bolts, all the castings are designed so that the bolts do not anywhere break into the inside of the motor.

EXPLOSION AND FIRE PROTECTION SYSTEM

The Graviner-B.S.R.A. oil-mist detector for preventing crankcase explosions (described in ENGINEERING of June 17, 1955, page 768), and standard industrial explosion-suppression equipment are among the exhibits on the stand of the Graviner Manufacturing Company Limited, Gosport, Hampshire. The explosion suppression and venting system was described in ENGINEERING (vol. 177, page 493, 1954), and it is now claimed that the Graviner equipment installed in the sulphur-grinding plant mentioned in that article has been successful in avoiding disastrous effects from explosions on five or six occasions since November last. One such system has also recently saved a wood-flour plant in Hull from the effects of an explosion.

During the past year the Graviner company have developed a high-speed isolation valve for use in conjunction with suppression or venting systems and one of these was on view on their stand. Used for isolating one part of a plant from another, to prevent the travel of flame during an explosion, these valves are very fast in operation; a valve for an 8 in. diameter duct closes in approximately 80 milliseconds.

Graviner were also showing their system for fire protection in Diesel railcars, particularly suited to the underslung exposed-type of engine installation currently in use on the Diesel-mechanical railcars operated by British Railways, Great Northern Railway (Ireland), Ulster Transport, and Coràs Iompair Eireann.

The detection system comprises a continuous-cord detector routed through the areas considered to be the most likely sources of fire, with supplementary unit resetting detectors in the vicinity of fluid flywheel or torque converters. The continuous detector consists of a steel capillary housing a pyrotechnic cord. The application of naked flame, or a rapid temperature rise above 250 deg. C., at any point in the length of the capillary ignites the pyrotechnic cord and the resultant pressure acts upon a small piston in a cylinder at the end of the cord. The piston movement is transmitted to a Tufnol plunger closing the contacts of a flame switch.

The unit detectors are of the differential expansion type in which a spring-bow assembly of low-expansion coefficient is housed in an alloy-steel barrel which forms the sensing element, of high coefficient. Expansion of the barrel as a result of sufficient temperature rise removes the compressive force from the bow assembly and permits a pair of contacts mounted on each of the spring-bow members, to close.

Operation of any one of the detectors automatically causes the discharge of chloro-bromomethane extinguishant from the bottles mounted on the rail-car underframe, through spray pipes directing the fluid to vulnerable parts of the engine.

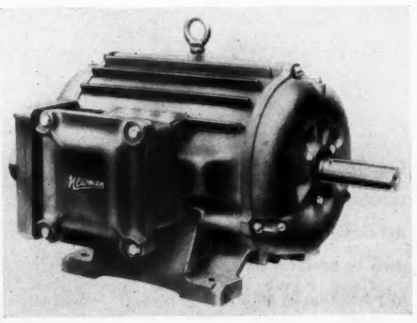


Fig. 73 Electric motor proofed for use in gasworks and other places of similar conditions. Newman Industries, Ltd.

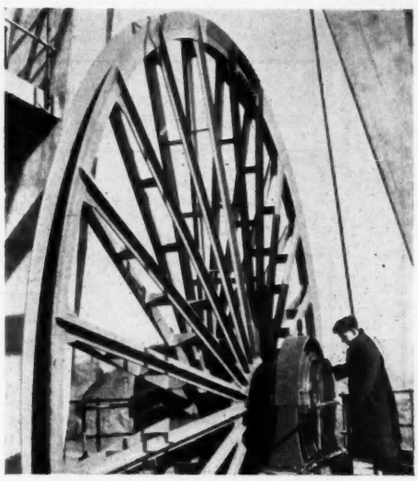


Fig. 74 18 in. extra-heavy split roller bearing supporting 55 tons at Bold Colliery, near Warrington. Cooper Roller Bearings Co., Ltd.

SPLIT BEARINGS

A full range of split roller bearings, from $1\frac{1}{4}$ in. bore and mounted in standard self-aligning housings and pedestals or connecting-rod ends, were displayed by Cooper Roller Bearings Company, Limited, King's Lynn, Norfolk. Components were sectioned where necessary to show the internal construction. The exhibits included three motor-driven working models to demonstrate the principle of the split roller bearing and its use in two typical applications: colliery screen crankshafts and marine intermediate shafting where vessels up to 23,000 tons have been equipped. Fig. 74, herewith, illustrates the installation of one of the company's 18 in. extra-heavy bearings at Bold Colliery, near Warrington. The total suspended load on the bearing is 55 tons.

Examples of solid roller bearings, typical of those made with bores from 2 in. to 100 in. were also being exhibited. They may be of a standard design or varied to suit customers' special requirements. Other exhibits also included separate cages, rollers and races and also a sectioned model of a Cooper " Safe " friction clutch.

SELF REGULATING ALTERNATOR

The Electric Construction Company, Limited, Bushbury Engineering Works, Wolverhampton, were exhibiting a self-regulating and self-excited alternator with a three-phase output of 18·75 kVA at 415 volts and 50 cycles when running at a speed of 1,500 r.p.m., the power factor being 0·8. It is driven by a squirrel cage motor. It incorporates a low-voltage revolving field which requires only two slip rings and consists of laminated poles with copper end dampers. The field windings are of copper, insulated with impregnated braided cotton and are rigidly secured to the poles. The stator windings are of Lewmex covered wires, which are also impregnated and are contained in semi-enclosed insulated slots.

The combined static exciter and automatic regulator consists of a double-wound transformer rectifier, transductor, bias rectifier, voltage sensitive control choke, rectifier, auto-

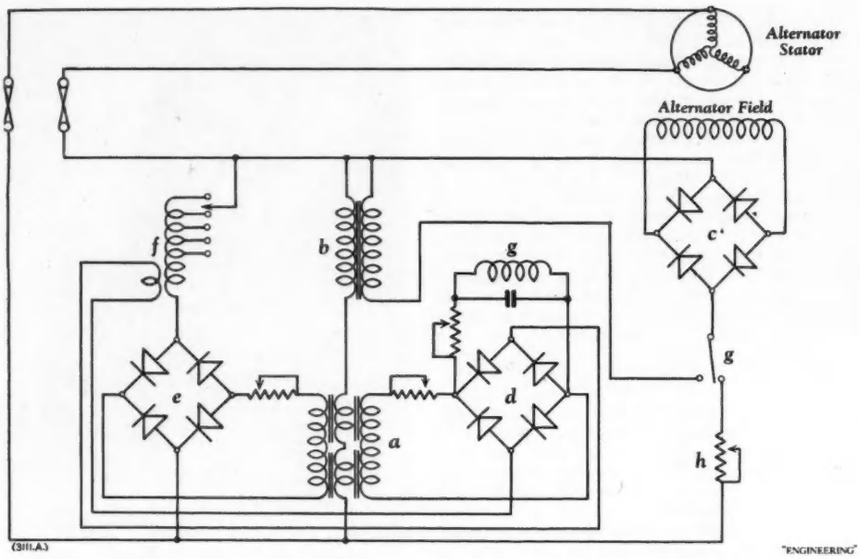


Fig. 75 Diagram of static-exciter for self-exciting alternator. Electric Construction Co. Ltd.

matic "start-auto regulate" relay and limiting resistance arranged as shown diagrammatically in Fig. 75. As will be seen the transductor *a* is in series with the primary winding of the transformer *b*, the secondary of which feeds into the alternator field through the rectifier *c* during normal running. The transductor, in addition to the variable-resistance alternating-current winding, has a saturating or bias-current winding which is fed from rectifier *d*, the latter being supplied with a voltage derived from the generator voltage. The second direct-current winding on the transductor is a control winding and is connected across the rectifier *e* and is in series with the saturated control choke *f*. The bias winding magnetises the core of the transductor to saturation and the control winding opposes the saturating winding. There is therefore a tendency for the magnetisation to be reduced so that the reactance of the alternating-current winding is increased. As regards control when the alternator voltage rises above normal, the reactance of the alternating-current winding of the transductor is increased and the current supplied to the alternator field is reduced. Consequently, the alternator voltage falls to its normal value.

To facilitate the building up of the alternator field on starting, the transformer *b* is cut out of circuit by a relay *g*. It is thus subjected to the whole of the generated voltage supplied to it through the rectifier *c* and the limiting resistance *h*. Then although the voltage generated owing to the residual field is small the alternator will excite rapidly. The relay *g*, which operates on approaching normal open-circuit voltage then changes over, disconnecting the alternator voltage from the rectifier *c* and the field winding; and connecting the secondary winding of the transformer *b*, which is a step-down transformer to the field rectifier and to the winding of the alternator.

COMPRESSORS AND PNEUMATIC TOOLS

Among the portable and stationary air compressors displayed by Broom and Wade, Limited, High Wycombe, Buckinghamshire, was a new portable rotary compressor capable of delivering 600 cub. ft. per minute of free air at 100 lb. per square inch. The compressor is directly driven through a gear-type coupling by a 180 h.p. Rolls-Royce C6.SFL supercharged Diesel engine running at 1,650 r.p.m.

They were also showing a range of pneumatic tools, and included among these machines was a new air-operated hand drill, the B.W.D.120. This drill weighs 7½ lb. and can be used with rotating drills or non-rotating chisels. It is particularly suitable for plug-holing, drilling foundation bolt holes in concrete, and chasing in brickwork, etc.

"UNIVERSAL" HYDRAULIC VALVES

A large range of hydraulic equipment was being exhibited by Keelavite Rotary Pumps and Motors, Limited, Allesley, Coventry. Among the items were pump/motor units for high-pressure power systems, for transmitting up to 300 h.p., and also a new range of control valves with wide applications.

These valves, two of which are shown in Fig. 76, may be called universal in that a large variety of operations can be carried out by them, using standard parts. They consist of a main spring-loaded piston valve, of nominal 1 in. size to which can be added a spring-loaded ball pilot valve. By re-arranging the standard components and connections, ten different types of operation can be obtained, each of which is capable of some four variations. Such operations as relief valves, direct or pilot-operated; flow-control; reducing valves with or without orifice control; and constant-pressure brake valves can be obtained. For systems which require pipe sizes larger than 1 in., the piston valve and pilot combination can be used as a direct pilot for the larger valve, by bolting the two parts together. Thus the same range of operations is available from the one unit whatever pipe-line size is in use. Being very compact, these control valves offer a great saving in space, and have the great advantage that a single set of spares can suffice for all the valves in a system, whatever their function.

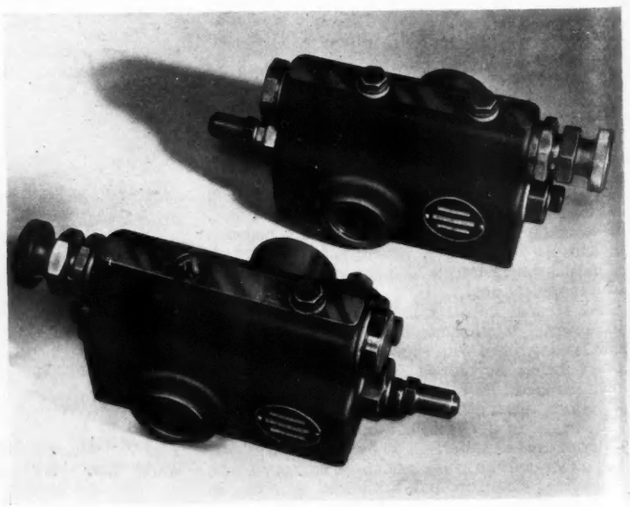


Fig. 76 Built up from standard parts, these hydraulic valves can be used to perform almost any function by suitable assembly. Keelavite Rotary Pumps & Motors Ltd.

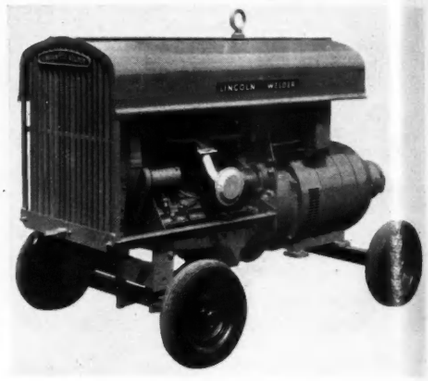


Fig. 77 Diesel-engine driven welder with dual control. Lincoln Electric Co., Ltd.

DIESEL-ENGINE DRIVEN WELDER

Lincoln Electric Company, Limited, Welwyn Garden City, Hertfordshire, were showing their new engine-driven welder with dual control, which is illustrated in Fig. 77 above.

The prime mover is a four-cylinder Fordson Diesel engine, the bore being 4·528 in. and the compression ratio 16 to 1. The cylinder block is of cast iron with replaceable wet liners and the cylinder head, which is of the same material, is of the detachable type. The connecting rods are of H-section steel and are fitted with shell pattern replaceable bearings, while the crankshaft is carried on five similar bearings. The solid skirt pistons are of aluminium; and the valves, which are of the vertical overhead push type are operated from a camshaft. Fuel is supplied by an injection pump, which incorporates a vacuum governor and easy starting device. Oil for lubrication is obtained from a submerged gear-type pump and cooling water from a thermo-siphon, impeller-assisted system, the circulation being controlled by a thermostat.

The compound-wound generator is mounted directly on the ball housing of the engine and its shaft is connected directly to the flywheel. It is of the single-operator variable-voltage type with a completely laminated magnetic circuit and requires no external reactance or stabiliser. Its direct-current range for welding duties is from 60 to 275 amperes at 40 volts and control is effected by adjusting both the shunt and series fields, the rheostat and regulating switch for these purposes being mounted on a panel. Excitation is obtained from an exciter which is directly connected through a sleeve to the shaft of the main generator. The engine, generator

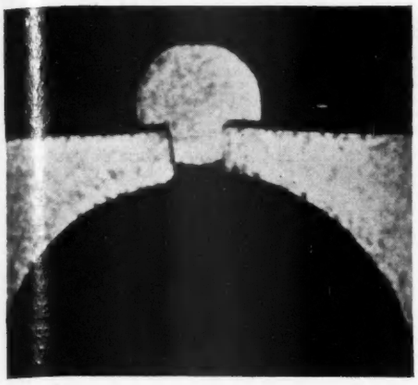


Fig. 78 Insert in position between the prepared surfaces of two pipes. Rockweld, Ltd.

and radiator are mounted on a channel frame, which is brazed and welded. As will be seen the equipment is protected by a canopy, so designed that clear access is possible.

E.B. WELD INSERT PROCESS

Rockweld, Limited, Commerce-way, Croydon, now have the sole selling rights for this country of the E.B. weld insert process of the General Dynamic Corporation of the United States. This process was first used on the atomic-powered submarine Nautilus, the piping systems of which carry radio-active fluids and can therefore never be repaired during the life of the ship. Reliable root welds are therefore essential to ensure that there are no crevices which might promote corrosion and cause failure.

The insert is simply a wire of special cross section obtained by machining, cold rolling and cold drawing. It is shown in cross-section in Fig. 78 fitted between the surfaces of two pipes. The internal surfaces of these pipes having been purged with argon gas, the insert is tack welded by an argon arc torch. The root pass is completed by playing the torch on to the insert and joint surfaces, the result being a capillary movement of the insert metal. The capillary forces are such that in welding the tube the internal surface contour does not depend on whether the weld is being made in the overhead, horizontal or working position.

ECONOMICAL WELDING EQUIPMENT

Rockweld Limited were also showing a new lightweight welding equipment (Fig. 79). It consists of an Enfield horizontally-opposed twin-cylinder Diesel engine which is air-cooled and is rated at 15·6 brake horse-power when running at 2,000 r.p.m. Its fuel consumption is less than 5 gallons for a working day of 8 to 10 hours when it is being used on high-duty cycle site welding. This result has been obtained by the employment of intensive air-blast cooling for both the engine and the generator. The result is that the generator can be overhung and perfect alignment ensured. The electrical output is 250 amperes for continuous hand welding and the combined unit is mounted on a four-wheeled trailer.

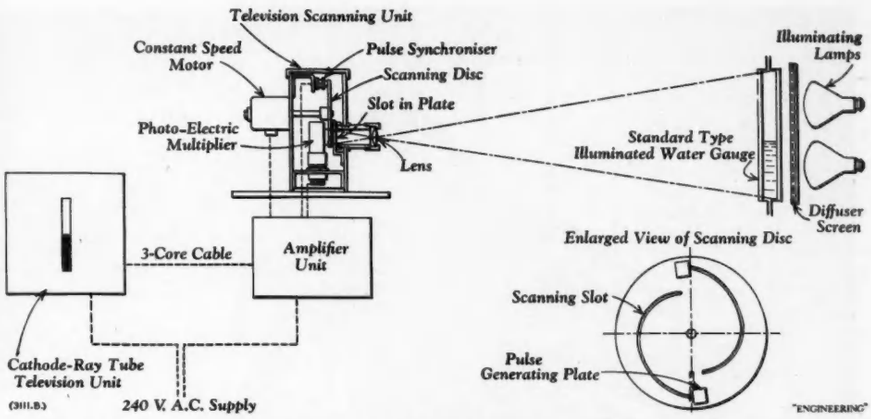


Fig. 80 Using a scanning disc with special slots and a constant speed motor, light impulses from the water gauge are transmitted through the scanning unit and amplifier to a display unit on a central control panel. Hopkinsons Ltd.

REMOTE WATER-LEVEL INDICATOR

A device for showing the water-level of large boilers situated remotely from the control panel was being shown on the stand of Hopkinsons Limited, P.O. Box B.27, Huddersfield. The equipment, which is shown diagrammatically in Fig. 80, consists of a scanning unit and amplifier, usually located together, and a display unit which can be located remote from the other units, as for example on a central control panel. The system is designed for use with a Hopkinsons prismatic-type water level indicator and does not need any external illumination. The illuminator on the water gauge is so designed that the steam space appears as a clear light and the water as a dark column.

The scanning unit is so placed as to permit the light from the gauge to pass through the camera lens, plate slot and scanning disc and on to a light-sensitive cell. As the synchronous motor-driven scanning disc revolves, each of its spiral slots moves downwards in a vertical plane across the narrow vertical slot in the plate; thus at any moment these spiral slots and the plate slot expose a small rectangular aperture through which any light emitted from the gauge may pass via the lens.

The light thus received impinges on the grid of the photo-electric multiplier which transforms the light impulses into electrical ones. These, in turn, are further amplified through the amplifier unit and pass to the cathode-ray tube of the display unit for transformation back to light impulses on the screen.

Also on Hopkinsons' stand were a manoeuvring valve with integral balance, a steam stop valve with steam cylinder for emergency closing by remote control, and a type "D" reducing valve. The above items are all recent introductions to the company's products and were exhibited for the first time. In addition there was the normal range of boiler mountings, valves and associated equipment for both land and marine installations.

RUST-PROOFING PROCESSES AND THEIR AUTOMATIC APPLICATION

Various industrial products for which they have provided corrosion-protection treatments, were shown on the stand of the Walterisation Company, Limited, Purley-way, Croydon, Surrey. Among the newer treatments is the Walterisation M.C. process, a rapid massive phosphating treatment giving a crystalline structure which has been specially designed to suit large-scale production techniques in industry. It is used for nuts, bolts, washers, brackets, unions, hand tools, springs, valves, castors, switch boxes and similar components. The process is not designed for the production of thin coatings for paint-bonding purposes, for which the firm have other processes available, but where maximum corrosion protection is required with a paint finish. The M.C. process sealed with at least three coats of paint is claimed to give excellent results. It is pointed out, moreover, that the coating has excellent lubrication and anti-scuffing properties which make it suitable for the rapid treatment of friction surfaces such as piston rings, gears, cylinder liners and tappets, and as a means of assisting lubrication in the deep pressing of steel-sheet components.

The M.C. process is particularly suited for application by automatic plants of the tipping-basket, conveyor or transfer types. The Walterisation Company are holders of a licence from the patentees, the Westinghouse Electric International Corporation of the United States, for the manufacture, use and sale of this type of plant in the United Kingdom and for export. The machine is operated pneumatically and controlled by hand. Machines can also be devised for all-hand or entirely hydraulic operation. It consists of a series of tanks each containing processing solutions or rinsing water. They include degreasing tanks, cold and hot-water rinses, phosphating solution and rinses and, finally, draining and drying equipment. The

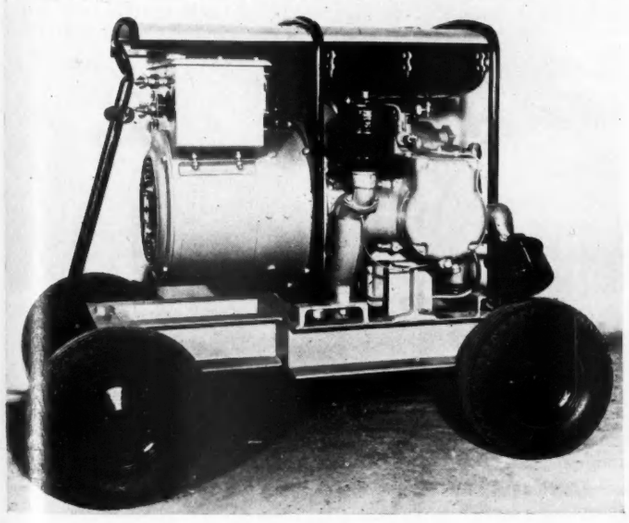


Fig. 79 15·6 brake horse-power lightweight Diesel engine-driven welding equipment. Rockweld, Ltd.

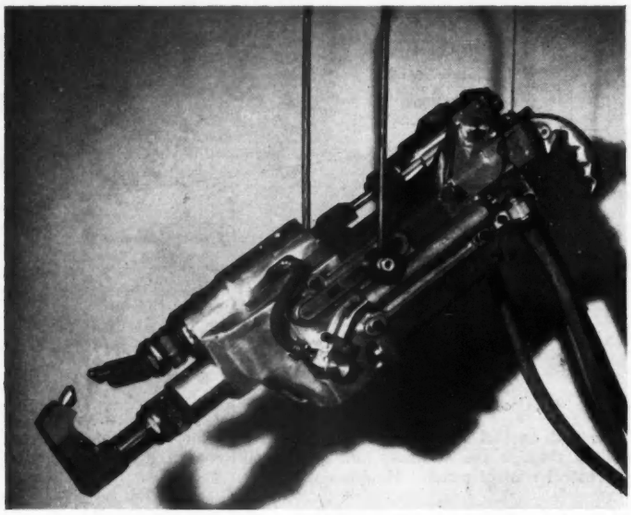


Fig. 81 Pneumatic gun for spot welding, particularly metal sheet. A.R.O. Machinery Co. Ltd.

baskets may be set so that they are tipped at predetermined intervals, this being usually 3 minutes. Thus, a batch of work which may require 9 minutes of phosphating, namely, immersion in three baskets each of 3 minutes' duration, can be delivered by the machine every 3 minutes. With hand operation, the weight of work in a basket is usually limited to 30 lb.; with pneumatic or hydraulic operation, 60 lb. may be loaded into each basket. The dry phosphated work is allowed to cool and is then finally dipped into the appropriate sealing medium, usually a special vegetable-oil base liquid which is compatible with most paints.

SPOT WELDERS

The A.R.O. Machinery Company, Limited, 18 Madrid-road, London, S.W.13, were exhibiting a range of spot-welding equipment, both portable and static. Shown for the first time was the P 413, an air-hydraulic gun for general purpose work, especially sheet metal welding. As the gun weighs 52 lb. it can conveniently be suspended from a stirrup for ease of movement. The electrodes are water cooled from a mains supply. The gun is shown in Fig. 81.

When the trigger of the gun is pressed, the electro-valve is energised and compressed air admitted to the hydraulic actuating valve. A " feed back " connection shuts off the supply of air when the hydraulic circuit has closed the electrodes, and at the same time switches on the welding current. When the weld cycle is completed—this can be governed by an automatic timer—the electro-valve re-opens and the air pressure is released allowing the electrodes to open. A pressure of about 660 lb. is exerted during the welding operation. Several different electrodes are available for use with this gun, giving a range of reach from 6¾ in. to 20 in. With the longest, flat sheets of 14 s.w.g. can be joined or rounds of ⅜ in. by ⅜ in. The automatic timer can be set to control both weld and forging times, the former having two ranges, from 0·05 to 0·5 seconds and from 0·35 to 1·5 seconds, and the latter being variable from 0·1 to 0·5 seconds. A switch gives the choice of single-spot or repetition operation—with a variation in interval in the latter case from 0·2 to 2 seconds. Nine current positions can also be chosen with, in addition, two step-up positions to compensate any voltage drop.

Another of the units on show was a portable " twin spot " gun, the DP 45. For demonstration, one of them was mounted vertically on rails and samples of flat sheet were welded together, the gun making the two welds simultaneously. The two electrodes have a clearance distance between them of 2 in. and are telescopic. The welding current cannot be switched on unless sufficient pressure is being exerted on both electrodes to make the weld effective. This pressure is adjustable between 55 and 250 lb. per electrode according to the material being handled. This type of gun is particularly suited for long seams or for straddling a channel section.

EIGHT-CYLINDER DIESEL ENGINE

Harland and Wolff, Limited, Queen's Island, Belfast, were unable, of course, to show any of their large marine engines. However, they exhibited a model of their opposed-piston pressure-charged two-stroke engine. This design was fully described in ENGINEERING earlier this year (February 4, page 154), and is a significant stage in the development of large oil engines for ship propulsion. The model exhibited represented an eight-cylinder engine designed for 6,000 b.h.p. at 220 r.p.m.

Another model of an important design was a one-tenth scale version of a blower unit driven by a gas-turbine and built for a large sewage-disposal works. This unit delivers 25,000 cub. ft. of free air per minute at 7½ to 9 lb. per square inch. for sludge purification. The turbine is of two-shaft construction and, by virtue of heat exchangers, it operates at a relatively high thermal efficiency.

The Diesel-engine generator set illustrated in Fig. 82 was one that Harland and Wolff were able to exhibit " in the flesh." It is an eight-cylinder four-cycle turbo-supercharged Diesel engine coupled to an H. & W. alternator and exciter. The set develops 625 kVA (720 b.h.p) at 600 r.p.m., and is typical of a range of Diesel alternator sets for land and marine use. Coupled to a direct-current generator, the same type of engine is used for ship's electricity supply.

Among the firm's other large exhibits were an H. & W.-Cooper-Bessemer compressor, typical of those supplied to oil refineries and the chemical industry here and abroad.

* * *

OVERHEAD-LINE JOINTING EQUIPMENT

Messrs. Tate Brothers, Limited, 100 Old Shoreham-road, Portslade, Sussex, have introduced an improved type of hydraulic compressor for jointing overhead electric transmission lines. This enables a joint to be made in less than 10 minutes on a steel-cored aluminium conductor with a copper equivalent of 0·4 square inch and consisting of 61 0·125 in. strands. In fact, a dead end clamp was recently made off in only 6 minutes thus representing a considerable saving in time over many other methods.

The new compressor is similar in principle to an earlier model* in having a twin opposed-ram action. The distance between the rams has, however, been increased to take the larger dies necessary for compressing the aluminium on a 61-strand cable. A small spacer block can also be inserted to allow standard dies for both steel and aluminium to be used. A feature of these dies is that the main body does not move, compression being effected by small keys in their faces. Wear is thus reduced.

The compressor incorporates a relief valve which makes a noise when full compression has been reached, thus avoiding both under and over compression; and the rams return to their off position automatically once the joint has been made. A further improvement is that the reservoir can be filled from the top of the table, thus facilitating maintenance. The compressor head is detachable for making-off non-tension joints on the tower cross arms and is then fed by flexible hose. This is not necessary when Tate clamps are used for anchoring, but has been employed by the Central Electricity Authority to replace " cone " and " parallel groove " non-tension joints where these have been installed in conjunction with " snail " clamps. Tate non-tension joints are designed in halves, which are bolted together so that each half will slide through the dies after compression. It is claimed that with this method of compression there is no " birdcaging " and that all the joints are quite straight.

* ENGINEERING, vol. 168, page 529 (1949).

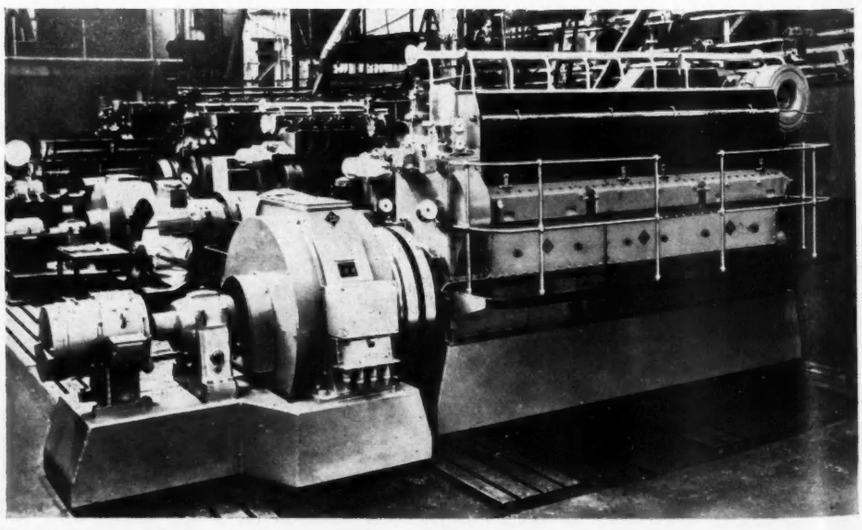


Fig. 82 Eight-cylinder turbo-supercharged Diesel engine coupled to a 625-kVA alternator. Harland and Wolff Ltd.

Fig. 1 To provide a factory large enough to deal with the entire I.C.I. output of copper tubes and to allow for future developments, the Kirkby plant has been built. Its design has been entirely conditioned by the processes, handling methods and products involved.

I.C.I. COPPER TUBE FACTORY

LONG DRAWBENCHES AND NOVEL HANDLING DEVICES CHARACTERISE KIRKBY PLANT

The Metals Division of Imperial Chemical Industries Limited has now been operating its copper-tube factory at Kirkby for some time. This plant, in which the entire process, from casting the billet to the finished tube, is carried out, is believed to be the largest factory of its kind in the British Commonwealth and to house the most powerful tube-drawing machinery in the world. The main mill—more than seven acres under one roof—is thought to be the biggest in the British non-ferrous metals industry. It is the result of a company decision to build a plant large enough to handle the whole of its present output of copper tubes and to allow for future development. A variety of interesting equipment has been installed and the draw benches themselves have been specially designed and built for I.C.I. by Head, Wrightson and Company. In addition to standard tubing, finned tube is produced by a novel process for such applications as refrigerators and heat exchangers, and some aluminium tube is also made. Mechanical handling plays a considerable part in the operation of the factory, and the building itself, which has been designed by Sir Percy Thomas, P.P.R.I.B.A., is of striking appearance, as can be seen from Fig. 1 above.

FACTORY BUILT ROUND PROCESSES

Since the whole plant has been built for a single purpose and since the design and installation is therefore entirely conditioned by the processes involved, it is important to consider first what these processes are.

The most suitable starting point is the casting shop where copper ingots, cathode copper and process scrap are melted in an Efco electric furnace, from which the liquid metal passes to an Ajax Wyatt-type holding furnace and thence into moulds of two sizes to form billets. The design of the holding furnace is interesting in that it consists of a main cylindrical vessel which is looped in parallel with a smaller cylinder. An induction heating coil surrounds the small cylinder and the metal circulates through both sections by convection. Both furnaces can be seen in Fig. 4. on page 468.

The billets then pass to a piercer situated at the head of A-bay, and this together with a preheating furnace deals with the smaller billets, piercing them to form a shell. The piercer is supplementary to an extrusion press in B-bay. A rotary swaging machine is followed by a squeeze pointer, which points the shells ready for drawing, and the shells then arrive at number one drawbench. Made by Head, Wrightson and Company, this bench is probably the largest in the trade and develops, with the aid of a 1,000 h.p. motor, a 300,000 lb. pull. Its maximum speed of drawing is 360 ft. per minute, three shells at a time, and the greatest length of tube drawn is 110 ft.

LONG DRAWBENCH AND FLOATING PLUG

Number two drawbench, which is capable of a pull of 100,000 lb., has a full speed of 450 ft. per minute and can draw three tubes at a time to a maximum length of 160 ft. Some indication of its great length is given by Fig. 2. The process on number three drawbench is the same as on number two, but from here the products have two alternative routes; they may be coiled and sent to the drawblocks or sawn into sections and transferred to B-bay as oddments, or to small domestic finishing benches in A-bay.

Incidentally, it may be interesting to note that the longer the bench the fewer times it is necessary to cut the tubes during production and hence the smaller the quantity of scrap. Furthermore the drawing speed can be increased since a long bench allows for the greater periods of acceleration and deceleration essential with high speeds.

The immense lengths of the Kirkby draw benches has been made possible by the use of a plug (or inner die) that requires no tie rod; if the length of a tie rod is excessive it undergoes elongation, so causing trouble. The floating plug remains in position by resting in effect on the shoulders of the outer die, and Fig. 3 indicates the manner in which this is achieved. Moreover, since tie rods are no longer needed, it is unnecessary to use a straight draw bench, and tube drawing, like wire drawing, can now be carried out on drums.

DRAWING TUBE IN COILS

This is illustrated by the next stage. From drawbenches two and three the tubes pass to Marshall Richards drawblocks or drawing drums, which continue to draw the full weight of the original tubes at speeds up to 1,800 ft. per minute. These units, one of which is shown in Fig. 5, can draw three tubes at once and employ the floating plugs previously described. When the installation was planned it was decided that the largest practicable drum diameter was approximately 5 ft., and in addition it was found by trial that the greatest size of tubing which could be drawn on drums of this diameter would weigh 1 lb. per foot run; these factors limited the weight of tube processed to 150 lb.

Drawblocks one and two operate on a horizontal axis, but number four has recently been

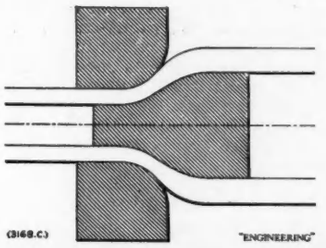


Fig. 3 The use of a floating plug, which is retained in position by the shoulders of the die, dispenses with mandrels and tie rods and permits longer drawbenches and the drawing of tube on drums or drawblocks.

Fig. 2 Number two drawbench (Head, Wrightson) can exert a pull of 100,000 lb., has a maximum speed of 450 ft. per minute, is 160 ft. in operating length and can draw three tubes at once. With long drawbenches fewer cuts in the tube are necessary and hence less scrap; higher speeds are also possible.

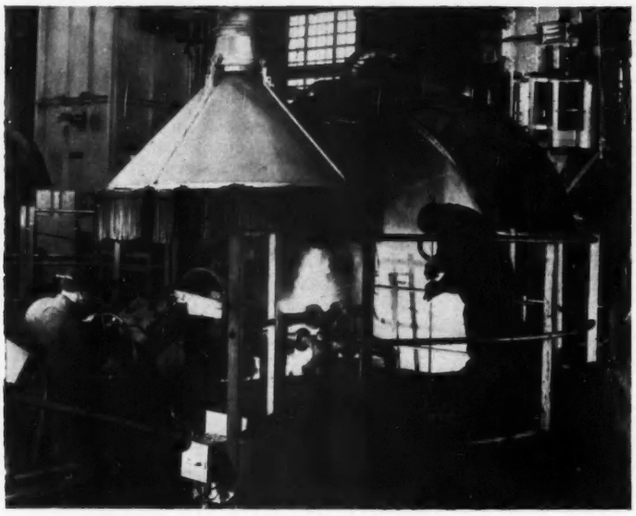


Fig. 4 The use of a large electric arc furnace for melting and casting copper is a comparative innovation in this country. An Efco furnace is shown here together with a small induction holding furnace (in front of the seated operator).

converted to work on a vertical axis; this effects a considerable improvement in coil handling. Drawblock number three is in process of conversion.

A special advantage of the drawblocks is the comparative ease with which the coils may be handled by a rigid-mast crane. In contrast, the task of using two gantry cranes and beams in tandem to convey the long straight lengths between the drawbenches presents conspicuous difficulties.

A LIMBO FOR BROKEN-DOWN CRANES

It is noteworthy that the design of the mill has been to some extent conditioned by crane operation; for example, at the centre cross-section of the building the roof has been raised in a hump to provide a gantry-crane loft. Thus if one of the numerous cranes breaks down, it can be lifted clear of the main track and suspended in the loft where it will not interfere with the working of the others.

The design of the mill and the layout of equipment has been very considerably influenced by the problem of handling in general. Floor transport was clearly an impossibility except at the finishing end, and it was evident that it would be necessary to rely entirely on overhead cranes. This meant that the three long drawbenches would have to be installed in line, each with its separate overhead crane or cranes; but to permit transfer of tubes from one bench to another all these cranes would have to be carried on the same gantry and this, it was realised, might result in excessive waiting time. Thus, in conjunction with the machine manufacturers, double loading and discharge mechanisms were designed, which eliminated the need for complete synchronisation of the overhead cranes and the drawbenches. Similarly, the problem of removing the coils from the drawblocks and supplying fresh material to them necessitated the design of the special rigid-mast crane shown in Fig. 6, (on page 469), the arm of which can rotate through 360 deg.

To cope with the output of the drawbenches and other demands, about six gantry cranes were required in each bay, and this would preclude a wide range of movement for any one crane. It was therefore decided to install a high-speed wall crane to run the full length of the building beneath the overhead cranes on the main track. Another feature introduced to simplify handling was a series of horizontal storage arms secured to the side of the building, which could receive coiled tube from the rigid-mast cranes and hold it until required.

After leaving the drawblocks the tubes are transferred to the end of A-bay where various ancillary operations are carried out; these include straightening, cutting-off, decoiling or recoiling, bright annealing, dehydrating and crimping. In this section hydraulic and electronic flaw-detection tests are also performed; all tube is inspected in this way before leaving the factory.

LARGE TUBES

Now that the main processes and the methods of handling have been considered it is possible to turn to particular parts of the plant, including various subsidiary sections not yet mentioned, and treat them in greater detail. There is, for example, at the warehouse end of B-bay, the large-tube area where Wellman Smith Owen benches are installed. Specially developed for plug drawing tubes up to 14 in. in diameter, these machines are highly mechanised with particular emphasis on quick tool changing. For tubes of larger diameter a hydraulic bench is provided and is the only one at Kirkby on which drawing is still carried out by the mandrel process. It is used for the production of finished tubes up to 17 in. in diameter. Near the hydraulic bench are numbers four and five drawbenches, which are standard Head, Wrightson 70 ft. benches installed at Kirkby in 1950.

EXTRUSION VERSUS PIERCING

One method of producing tube shells and certain other products requires the use of extrusion presses, and there are two Fielding and Platt machines for this purpose at the I.C.I. plant. One is a back extrusion press of 1,500 tons capacity, which forms large-diameter tubes by forcing a steel nose into the centre of the hot billet, and is also used for the production of solid rollers; while the other is a forward extrusion press of 2,500 tons capacity, which can handle a 450 lb. billet and extrudes a shell 30 ft. long, that is approximately three times the length and weight of a shell formed on the piercer. Incidentally, with back extrusion it is not always possible to obtain a surface completely free from scale, so at Kirkby all the hot-punched rolls are machined before being passed forward for cold drawing.

In selecting the machinery for making tube shells a number of factors were considered. In the manufacture of tubes under 2 in. in diameter, there are two methods of processing the solid cast billets into a hollow tube, both of which—as opposed to drawing, which is a cold operation—are carried out with the metal at a temperature of approximately 850 deg. C. The first method is piercing, in which the hot billet is rotated between obliquely set barrel rolls and simultaneously fed forward over a plug; the plug drives its way through the centre of the hot billet, so producing a tubular form, or shell. The other method is extrusion, in which hot metal from the solid billet is forced through a die and over a mandrel so that the metal is expelled from the container in tubular form. From a comparison of the two processes it was concluded that the best plan would be to concentrate on extrusion using a 2,500/500 ton press, but an existing piercer, to which reference has already been made, was also installed so that, after suitable modernisation, it could be used as an auxiliary.

It is also interesting to note that until Kirkby was built, the copper billets for piercing or extrusion were cast in this country, as far as is known, either in small electric or gas-fired furnaces or in large reverberatory furnaces, used principally for the refining of copper from blister slabs. It was known that in America the arc furnace used in the steel industry had been modified for melting and casting copper, and after investigations I.C.I. also decided to adopt this practice. In this type of furnace melting and pouring are virtually continuous.

COPPER ROLLERS FOR PRINTING

In addition to the main production processes at Kirkby, there are a number of special items which are also worthy of attention. Among the tube products made by I.C.I. are copper rollers for textile printing and electro-deposited rollers for textile and paper printing. This work was originally carried out at Broughton Copper Works, and on its transfer to Kirkby these departments were modernised. Solid rollers are produced from the cast billet on the back extrusion press, like the shells for large tubes, but during the punching operation a key is formed in the bore of the shell. The shell is then cold rolled, fitted accurately on a tapered mandrel by mechanical hammering, turned to size and polished. The finish of the polished roller is of the greatest importance and a Taylor, Taylor and Hobson Talysurf machine is used for checking, which gives a graphical picture of the surface correct to one micro-inch.

Copper deposited on either a copper or cast-iron base is also used for textile printing, and electro-deposited rollers have also been in demand for photogravure printing in recent years; by close control of the electrolyte and current denisity deposits of constant high quality are ensured.

INTEGRAL FINNED TUBE

A recent development in tube fabrication has been the " Integron " finned heat-exchange tube. As distinct from finned tube in which the fin has been wound or brazed in place, the Integron fin is integral with the tube. It is formed in a similar manner to thread rolling, by rolling a thick-gauge tube so that most of the metal in the wall is displaced into the fins. Tube of this kind can be produced with a high or low fin; in the low-fin type, short sections of the original tube

Fig. 5 Marshall Richards drawblocks are operated at the Kirkby factory in both horizontal and vertical positions. They can draw three tubes simultaneously at speeds up to 1,800 ft. per minute using the floating plugs shown in Fig. 3. Coiling of the tube simplifies handling.

Fig. 6 Handling is particularly important at Kirkby. Cranes employing a horizontal rigid mast, which can rotate through 360 deg., have been designed for moving the coiled tube.

are left untouched at intervals by "skipping," to provide points at which the perforated heat-exchanger tube plates can be fitted.

The advantages of integrally formed fin tube include greater efficiency of heat transfer since there are no discontinuities between tube and fin, improved resistance to vibration since the tube cannot become separated from the fin, ease of production, and adaptability since the tube can be bent without difficulty. As an indication of its heat-exchange qualities, it has been pointed out that one inch of $\frac{7}{8}$ in. bore Integron tube has the same surface area as ordinary straight tube of the same bore 9 in. in length.

Finned tubes are produced in copper, aluminium and a number of copper alloys. It is also possible to produce bi-metal finned tubes, in which the fins and outer wall are in copper or aluminium and the inside of the tube in steel, titanium or any of the copper alloys. Other tube-fabricating operations carried out at Kirkby are the manufacture of artillery shells and of cable sockets from copper tubes.

PORTAL-FRAME CONSTRUCTION TO LIMIT DUST

The nature and extent of the machinery largely determined the character of the buildings which were to house it, for the factory was to be designed round the manufacturing operations involved, and particularly that of tube drawing; this presented the consulting architect Sir Percy Thomas and the I.C.I. engineers with a number of special problems. The layout of plant, and in particular the need to place the three largest drawbenches end to end, called for a main production unit a third of a mile long. A second overriding requirement was the necessity to avoid ledges and lattice girders which would harbour dust, since dust on the surface of tubes during the drawing operation would have a seriously deleterious effect.

The design finally adopted for the main production unit, the tube mill, comprised an all-welded double-bay structure, with each bay 1,530 ft. long and 90 ft. wide; the inside height would be a clear 30 ft. to the eaves and the height of the arch 60 ft. at the centre. To avoid dust traps portal-frame construction was adopted —a feature with the additional advantage of enabling overhead cranes to be housed in the roof space while still retaining the maximum lift required for working.

One of the bays accommodates five overhead cranes and one rigid-mast crane; the other, five overhead and two rigid-mast cranes. Both bays are equipped with travelling jibs, each of 4 tons on a 15 ft. arm, which run the full length of the building on each side of the valley and pass underneath the overhead cranes. The gables are designed to carry 5 ton Semi-Goliath cranes.

The third bay was required to house service sections. To reduce the volume, this was designed as a single-storey flat-roof structure, 28 ft. wide and 18 ft. high, running almost the full length of the main building. Smaller production units (casting shop and roller department) and ancillary units such as offices, stores canteen, boiler house and fire station are housed in separate buildings. The casting shop and roller department buildings are of high-low steel-frame construction with roofs clad in Ruberoid steel deck insulated on the ouside and covered with Ruberoid felt.

All the buildings have 11 in. cavity walls and 6 in. reinforced concrete floor bases with $\frac{1}{4}$ in. granite finish, powdered and dressed with carborundum. The total superficial area of the buildings is more than 470,000 sq. ft.

HEATING BY HIGH-PRESSURE WATER

The question of space heating the main mill, of 13,788,000 cub. ft. capacity, was a major problem. As a step towards solving it the roof was clad with corrugated aluminium-alloy sheets, lined with $\frac{1}{2}$ in. insulating boards and an inner layer of 0·009 in. aluminium foil, giving a coefficient of thermal transmittance of the order of 0·2. Walls were also lined with $\frac{1}{2}$ in. insulating boards. To minimise the temperature gradient from floor to roof it was decided to install radiant panel heating served by high-pressure hot water; this was chosen rather than steam to eliminate steam traps and to dispense with make-up or a water purification system. These advantages arise since water under pressure can reach high temperatures without boiling.

Special attention was given to natural lighting. To reduce the total area of roof lights, and so limit heat loss, it was agreed to adopt star lighting, using corrugated Perspex panels. This system, not only ensures uniform light distribution, but also requires no additional steelwork and provides watertight and dustproof lights.

The demand for cooling water, which is used in the production processes, is unusually heavy at Kirkby and is catered for by collecting in a central reservoir, with a capacity of $1\frac{1}{2}$ million gallons, all storm water from the roof of the seven-acre main mill. This also serves as a source of water for fire-fighting purposes, the pumps for which are operated by remote control from the fire station.

CHIMNEY-STACK WATER TOWER

The boiler house is equipped with three economic boilers of the high-velocity, self-contained type, each producing 10 million B.Th.U. per hour, with room for one further addition. The boilers provide a high-pressure hot water supply, principally to the panel heating system. The small amount of process steam required is supplied by steam generators from the hot-water system.

From the point of view of temperature control, the factory is divided into a number of separate zones, and the output of the boilers is automatically controlled according to the temperature required in each zone. An interesting feature of the boiler house is the stack, which was designed in reinforced concrete with a broad cylindrical band at the top forming a water tower of 25,000 gallons capacity. The object of combining both units was to reduce the number of high structures on the site.

TUBES FOR ATOMIC POWER PLANTS

Although the output of the Kirkby factory meets an immense variety of demands, there are a number of general sections into which the products can be divided. More than 30 per cent. of the tubes are used for domestic purposes and the remainder for engineering, including shipbuilding and refrigeration. Copper tube is also employed for heat-exchange plant in thermal atomic power stations. Approximately half of the domestic tube is sent overseas.

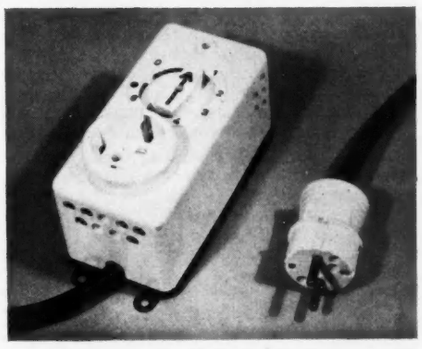
The contracting firms for the plant and equipment installed at Kirkby include: Head, Wrightson and Company, Limited, Thornaby-on-Tees, Yorkshire; Marshall Richards Machine Company, Limited, Crook, Co. Durham; the Wellman Smith Owen Engineering Corporation, Limited, Wilton-road, London, S.W.1; Fielding and Platt, Limited, Gloucester; Efco Engineering Company, Limited, Queens-road, Weybridge, Surrey; the Vaughan Crane Company, Limited, West Gorton, Manchester, 12; Taylor, Taylor and Hobson Limited, Leicester; and the Ruberoid Company, Limited, 1 to 19 New Oxford-street, London, W.C.1. Reference has already been made in the text to the items contributed by these firms. The contractors responsible for the building work were R. Costain and Sons (Liverpool), Limited, Barlows-lane, Fazakerley, Liverpool, and for the steelwork Robert M. Douglas (Contractors) Limited, 395, George-road, Erdington, Birmingham.

* * *

ELECTRIC HEATER REGULATOR

A unit for the regulation of electrical heating apparatus has been produced by the Stabilag Company, Limited, Mark-road, Hemel Hempstead, Hertfordshire. Known as the Electrotap, it operates by making and breaking the circuit for short periods; in this way the power consumption of a heating apparatus can be regulated from zero up to 60 per cent. of its normal full load, or it can be switched full on.

The unit, which is shown in the illustration,



By varying the on/off time ratio, the Electrotap regulator can control the input to electrical heating equipment from zero to 60 per cent. of full load.

above, is the same size as a normal switch-socket combination. It should always be used suspended in a vertical position. The pilot unit consists of a heated bimetal strip, the position of which is altered by the control knob to give the appropriate on/off time ratio. There are eight control positions, "off," 4, 13, 23, 34, 46 and 60 per cent. load, and full "on." Two types are made, one with plug and socket, and the other with terminal connections. Both are contained in white plastic cases with neon indicator lamps. The overall dimensions are approximately $5\frac{1}{2}$ in. by $2\frac{1}{2}$ in. by $2\frac{1}{2}$ in.

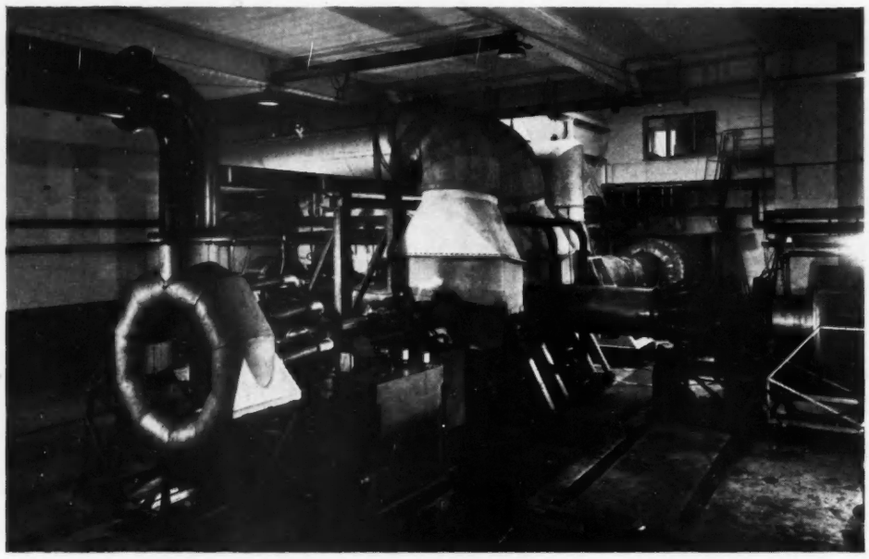


Fig. 1 Two Ghost-driven exhaust turbines supply the main shaft power for the gas-dynamics laboratory.

Fig. 2 The first section of the silencer is telescopic to allow for varying jet pipelengths. Further adjustment can be made by removing sections of the silencer ducting, which is made in 6 ft. lengths.

THE GYRON ON TEST

DE HAVILLAND JET DEVELOPMENT FACILITIES

Representatives of the Press were recently given the opportunity of seeing the 15,000 lb. thrust Gyron turbojet running on its testbed at the Hatfield plant of the de Havilland Engine Company, Limited, Stag-lane, Edgware. This new test house is capable of handling the air mass flows demanded by engines with thrusts in excess of 20,000 lb., and of testing these engines at outputs greater than 30,000 lb. thrust with afterburning.

NOISE SUPPRESSION

Silencing of the installation is effectively carried out by an acoustic-splitter type of intake and an exhaust silencer terminating in twin detuners of the largest size (Fig. 4), the whole of the exhaust installation being supplied by Detuners Limited, Flowers-mews, London, N.19. At the present thrust rating, without afterburning, the visitors were able to observe that the noise level immediately adjacent to the detuner exits is completely unobtrusive and unobjectionable.

In combining the air supply for cooling the steel detuner with that required for engine operation, a system of two-stage air entrainment has been employed. By this means a flow of non-turbulent air for the engine at a constant and known temperature and pressure has been achieved, with no flow-back of warm air from the jet pipe—a point of significance, the de Havilland company point out, since a 1 deg. temperature rise near the intake could result in the loss of some 100 lb. of thrust.

The air for combustion and for the first stage of cooling enters through the main intake at the front of the building. At this stage the ratio of cooling air to engine air is about 1·5 to 1. The entrained air is induced into the silencer by the exhaust from the engine. A second intake in the test-house roof supplies a similar quantity of additional cooling air which is again induced into the silencer itself beyond the test cell, further diluting the hot exhaust gases. The total amount of air entrained is thus three times the engine flow.

To allow for varying jet-pipe lengths, the entry to the silencer is telescopic and can be manually adjusted (Fig. 2). The length of the telescopic section is 15 ft., but further adjustment is provided by making the forward part of the silencer duct in 6 ft. detachable lengths. An electric hoist is permanently installed in the roof for handling the detuner sections.

FREELY-SUSPENDED ENGINE

The engine to be tested is prepared in an adjacent workshop and is conveyed into the test cell on a rail-mounted trolley. At the installation point the entire trolley is lifted on a hydraulic-pneumatic ramp which brings the engine and its mountings in line with four rods suspended from transverse roof girders. The engine is thus freely suspended, although four safety trunnions are placed loosely around the mountings in order to take any out-of-balance loads which might arise in the event of a major component failing during the test. At the forward end the engine bears against two thrust pads of conventional design. Some 400 pressure tappings on the engine can be connected with 10 in. full-scale gauges or to manometers in the control room through twin panels in the roof (Fig. 3), and a third panel beside the engine provides for electrical-instrument connections.

The control room is adjacent to the test cell and will ultimately serve a second test cell to be erected on the opposite side. The engine is visible through an armour-plated window, and the main engine instruments are shown on the left. The engine controls are operated through an Exactor hydraulic-transmission system. In addition to several electronic multiple-channel instruments of the direct-reading type, there are electronic chart recorders and a battery of water

Fig. 3 The engine is freely mounted on four suspension rods hanging from the roof. Pressure tappings are connected with instruments in the control room through twin panels on the roof. Below the engine can be seen the hydraulic-pneumatic ramp which raises the engine on its handling trolley for installation on the test bed. The trolley is removed after installation has been completed.

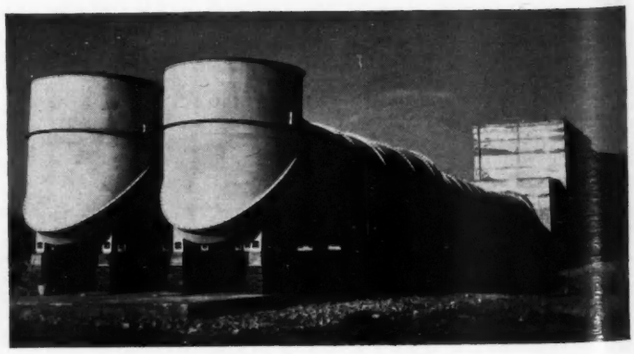


Fig. 4 Silencing of the engine exhaust is effectively carried out by a large bifurcated detuner.

and mercury manometers which give a continuous indication of the pressure variations in the engine and the changes in mass flow.

FIRE PRECAUTIONS

In the test cell, safety precautions include large extractor fans which remove any accumulated fumes. Spilt fuel is led away through a floor channel through an anti-flash sump to a drain outside the test house. The operation of a single switch on the control panel causes the fuel pump to be switched off and the main fuel-inlet valve to close; at the same time the extractor fans are switched off and electric motors close down roller shutters over the test-cell intake. A primary charge of carbon dioxide is discharged through nozzles around the engine to prevent the immediate spread of flame. When the test cell is sealed off from the atmosphere, a second and larger discharge of extinguishing fluid floods the test bed. These precautions are expected to extinguish most fires, but as a further safeguard a "backing-up" switch discharges a larger volume of additional carbon dioxide if signs of burning still persist.

To ensure uninterrupted running of the engine, a total capacity of 50,000 Imperial gallons of fuel is provided in four overhead tanks outside the building. These tanks are supplemented by an underground fuel installation with a capacity of 100,000 gallons. Experimental running often requires the use of various grades of aviation fuel, and a network of fuel lines and valves makes it possible to run the engine on any one of a large selection of fuel tanks. Fuel is supplied by a low-pressure fuel pump controlled by constant pressure valves. To cater for afterburning, a fuel-flow capacity of more than 10,000 gallons per hour can be obtained.

GAS-DYNAMICS LABORATORY

The components of the Gyron engine have been developed by full-scale testing in de Havilland's well-equipped gas dynamics laboratory, also situated at Hatfield. Here, shaft power is supplied by Ghost engines driving power turbines, and the air supply required is furnished partly by Ghost compressors and partly by electrically-driven reciprocating compressors.

In the main compressor test cell (Fig. 1), the power unit comprises two exhaust turbines each driven by the exhaust from a Ghost turbojet serving as a gas generator. The two power turbines can be coupled together to give a 10,000 h.p. shaft drive, or they can be used individually to drive a Ghost compressor at full duty to provide an air supply of about 80 lb. per sec. at 60 lb. per sq. in. for work on the combustion, air-flow or turbine test rigs. Using the output from both power turbines, large compressors can be tested by running under closed-cycle conditions and reducing the density in the closed circuit. This enables the effects of Reynolds number on compressor performance to be checked. The air in the closed circuit is cooled by passing it through a series of coolers and expanders.

Ultimately, there will be three of these twin Ghost power units serving the laboratory, giving a total shaft power of 30,000. The second unit is now under construction.

There are also smaller power units comprising single Ghost turbines for driving compressor-stage and turbine test rigs. In the case of the turbine test rig, the compressor of the Ghost power unit is used as a vacuum pump to suck air through the turbine under test, and the air for combustion is supplied by the electrically-driven compressors of the "house supply." The power developed by the turbine under test is absorbed by a calibrated dynamometer. To prevent ice formation in the turbine rig, some of the outlet air from the engine compressor is ducted to the test-turbine inlet to mix with the atmospheric air entering the turbine.

The laboratory also provides rigs for testing annular combustion chambers, rigs for determining the air-flow characteristics of components, an altitude chamber, and a wind tunnel. To expedite the work, which involves a large number of temperture and pressure measurements, automatic chart recording mechanisms are used.

THE AIRCRAFT INDUSTRY DISPLAY

(4) RESEARCH, DEVELOPMENT, EQUIPMENT

The Ministry of Supply stand, displaying each year some new aspects of the work of the Government research and development centres, is always one of the principal centres of attraction at the Farnborough static exhibition. This year the National Gas Turbine Establishment, currently much concerned with the generation of powered lift, displayed models, photographs and wind-tunnel demonstrations illustrating the principle of the jet flap which, they say, "incorporates a new dynamic principle which is nowhere to be found in nature."

THE JET FLAP

Substantial increases in lift coefficient have been obtained by N.G.T.E. in wind-tunnel model tests of the jet flap, which operates as follow. The whole of the exhaust jet from the propulsive gas turbine is discharged from the trailing edge of the wing in the form of a long thin spanwise sheet. In high-speed flight this jet issues horizontally so that the aircraft would behave more or less like any normal machine. In low-speed flight, when it is desired to increase the lift for take-off, or landing, the jet would be deflected downwards to form a "flap." This deflection of the exhaust jet would probably be brought about by means of a small curved mechanical flap, utilising the Coanda effect.

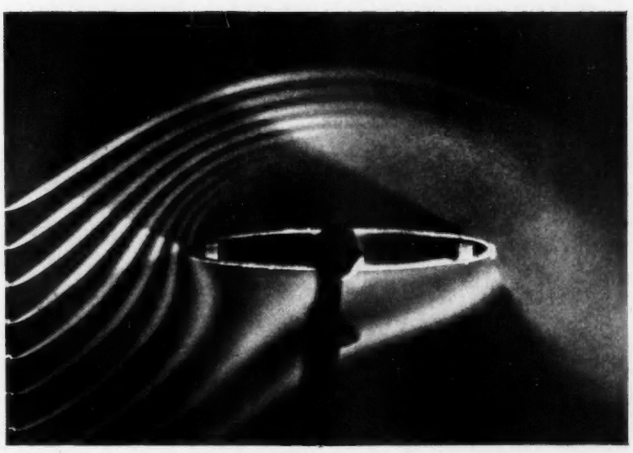
Since the jet flap acts in a similar manner to a conventional flap by modifying the circulation round the wing, it is not a vertical take-off device and requires forward speed. With the jet flap deflected downwards through 58 deg., a lift coefficient of 12 has been obtained—i.e., at least four times the lift obtainable with the best existing slotted-flap arrangements. N.G.T.E. consider that, with suitable ducting, the jet flaps will result in very little loss of thrust either at high or low speed. The action of the flap is shown in Figs. 19 and 20 below.

The aircraft destined to use jet flaps will have to be specially designed, for the device cannot be fitted to existing aircraft. It is probable that a number of small engines will ease the ducting problems, and will also give a greater measure of safety in the event of engine failure.

KINETIC HEATING

Also on view on the Ministry of Supply stand were exhibits by the structures department of the Royal Aircraft Establishment, the principal item being concerned with simulating kinetic heating effects during structural tests. To assess the stresses that may be produced in an aircraft at high supersonic speeds it is necessary to reproduce the aerodynamic heating, correctly distributed over the surface and varying with time as the aircraft accelerates, in addition to the mechanical loads. An effective method of producing the required heat is by infra-red lamps, since the convection losses are low and there is no delay in gaining full power. One of the exhibits was a quartz tubular infra-red heater with an output from 0 to 3 kW, made for the R.A.E. by Philips Electrical Limited, Shaftesbury-avenue, London, W.C.2. It is shown in Fig. 21, on page 472. This is believed to be one of the highest-powered incandescent filament lamps of its size. Heaters of this type can be closely packed, in gold-plated steel, to produce radiation densities up to 50 kW per square foot. At maximum power the tube has a life of 100 hours.

The main exhibit illustrated the introduction of "automation" into structural testing, which is now under development at R.A.E. A structural specimen, with blackened surface to assist in absorbing the heat energy, receives heat from banks of individually-controlled infra-red tubes above and below its top and bottom surfaces. By this means the correct distribu-



Figs. 19 and 20 In both figures, the air flow is from left to right. Fig. 19 shows the jet flap at zero incidence. Fig. 20, in which the jet flap is deflected through 58 deg., shows how the suction over the upper surface is increased; in this configuration a lift coefficient of 12 was obtained on test. National Gas Turbine Establishment.

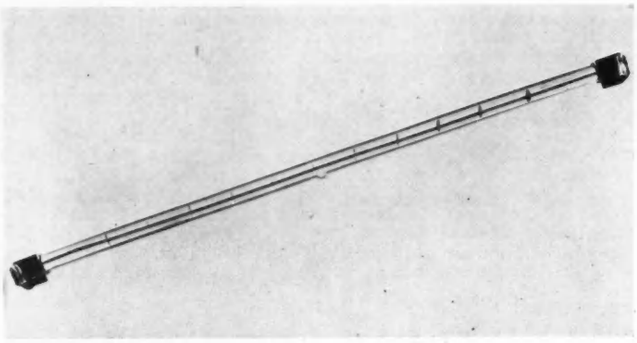


Fig. 21 3 kW infra-red heater: Philips Electrical, Limited.

tion of heat over the surface can be maintained. The automatic control equipment comprises three sections—a "heat-required" computer, heat flux measuring instruments, and a servo controller. These units are shown in Fig. 22, which shows part of the M.O.S. stand.

The heat-required computer, fed with the appropriate aerodynamic data for the flight conditions under test, and continuously measuring the surface temperature of the body at a number of points, calculates the instantaneous heat energy required at each section of the specimen surface to simulate the kinetic heating effect. The heat flow absorbed by the specimen is measured by the heat-flux measuring instruments. The servo controller, made for the R.A.E. by the English Electric Company, Limited, compares the computed values of the heat required with the measured output of the lamps and continuously corrects the output to give zero error.

For measuring heat flux, the R.A.E. have developed a total radiation-flux meter in which a thermistor bead is used as the heat-sensing element, with a resistance highly sensitive to temperature and of exceptionally rapid response. A change of radiation flux from 0 to 4 watts per square centimetre results in a resistance change from 2,000 to 600 ohms.

Also on view was a model of a projected structural test rig incorporating kinetic heating simulation, in which the heaters are arranged in ovens placed around the structure, and freely suspended so as to place no load on the specimen. Mechanical loading is applied conventionally.

COMPUTERS

Electronic computing machines are increasingly used by the aircraft industry for the solution of flutter problems, the resolution of performance results, evaluating the characteristics of servo-mechanisms, etc., and several of the aircraft firms have developed their own installations. Short Brothers and Harland, Limited, Queen's Island, Belfast, have developed an analogue computer for general application in industry and research. At Farnborough this unit was on view, as was also one of its applications, an aircraft handling simulator which enables a projected aircraft to be "flown" before it has been constructed.

Saunders-Roe, Limited, East Cowes, Isle of Wight, have also done much work on analogue computers, and exhibited two models—a medium size machine and the Miniputer, shown in Fig. 23, which is described as a "table top" analogue computer for preliminary design investigations and educational purposes.

Another analogue computer on view was the G-PAC (general purpose analogue computer) displayed by Elliott Brothers (London), Limited, Century Works, London, S.E.13, a small commercial machine designed under a Ministry of Supply development contract with a view to making its operation as simple and cheap as possible. It consists of a self-contained cabinet housing both power supplies and functional units, and operates on a 200-250-volt 50-cycle single-phase supply; the consumption of a single cabinet—which can house up to 20 functional units—is 1·2 kVA.

A new medium-sized digital computer, the Pegasus, was shown by Ferranti, Limited, Hollinwood, Lancashire, claimed to be exceptionally versatile. Pegasus is built from standardised plug-in packaged units for ease of maintenance and replacement. Computation is carried out in a high-speed store comprised of nickel delay-lines, to each of which there is immediate access. The main storage is a magnetic drum with a capacity of over 4,600 words. The standard equipment for input and output of information uses punched paper-tape, and auxiliary equipment with punched cards or magnetic tape is under development.

Since there were over 280 exhibitors showing at the recent Society of British Aircraft Constructors' display showing aircraft equipment, accessories, ancillaries and materials, in addition to the main aircraft and engine constructors, it is impossible to do more than a brief mention of a few of the newer items that attracted our attention.

FLIGHT INSTRUMENTS AND CONTROLS

An important development in instrumentation is the Smiths Flight System shown by Smiths Aircraft Instruments, Limited, Cheltenham, which considerably simplifies the pilot's task under instrument-flying conditions by integrating the information relating to the V.O.R. navigational system, the I.L.S. (instrument landing system) and the standard directional gyros and condensing the functions of 16 different indicators into eight easily-read panel-mounted indicators. The system can, moreover, be linked with a Smiths S.E.P.2 autopilot, giving facilities for course steering, turns on to pre-selected headings, the maintenance of constant pressure altitude, airspeed monitoring, V.O.R. beam tracking and fully automatic approaches on I.L.S. The new system has already been specified by British European Airways for 26 Viscount Major aircraft now on order and by British Overseas Airways Corporation for their future Britannia 300 and 300 LR fleet.

Another aspect of the integration of flight control is the co-ordination of manually-regulated hydraulic power controls with the automatic pilot and with autostabilisers. By careful matching of the automatic pilot and power control systems, it is possible to eliminate many of the amplifiers and servos hitherto used in the autopilot system, with a consequent saving in weight. Such a system was demonstrated by Boulton Paul Aircraft Limited, Wolverhampton, incorporating a miniature control column which transmits electrical signals to the power unit in response to the pilot's movements. The Elliott-Hobson system, which has the same object, has already been outlined in the September 16 issue of ENGINEERING (page 389), and a similar development has been announced by the Sperry Gyroscope Company Limited, Brentford.

RADIO AND RADAR

Several new radio, radar and navigational aids were on view, among which the new 3-cm. ground radar type MR75, shown by Decca Radar Limited, 1–3 Brixton-road, London, S.W.9, has many interesting features. It is designed to fill the gap between complex long-range early-warning radars and the short-range approach aids, and is a compact low-cost installation suitable for small local airfields as well as for national air-traffic control schemes. It can be equipped with the new Decca universal fixed-coil display, which is said to be much more versatile than the conventional rotating-coil display.

Marconi's Wireless Telegraph Company, Limited, Chelmsford, showed several new developments including their sub-miniature automatic direction finder, AD 722 (Fig. 24), believed to be the smallest and lightest of its kind, of only 20 lb.; and an automatic fixed system for use with V.H.F direction finders types AD200 and 210, which enables a ground station to make an almost instantaneous fix on any aircraft equipped with a V.H.F transmitter.

The Canadian Marconi Company showed a lightweight aircraft radio compass, weighing only 30 lb. in all, compact yet highly sensitive; and a take-off monitor which indicates, in effect,

Fig. 22 RAE's kinetic-heating exhibit: from left to right, the test specimen and its heaters, the heat-required computor and the servo controller. On the right is the model structural test rig incorporating heaters to reproduce the effects of kinetic heating. Ministry of Supply.

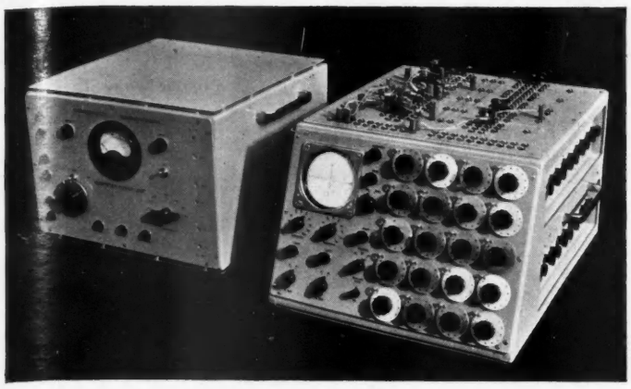


Fig. 23 The Miniputer table-top analogue computer. Saunders-Roe, Limited.

the relation between acceleration and airspeed at all times during the take-off run, and informs the pilot if the acceleration is above or below the value needed to make good the take off.

TACAN, the new air navigation system exhibited by Standard Telephones and Cables Limited, Connaught House, Aldwych, London, W.C.2, was described in the August 26 issue of ENGINEERING. This company also showed for the first time an U.H.F. direction finder operating in the frequency band 225–400 megacycles, with remote selection on any one of ten preset frequencies; and their SR32/33 combined I.L.S/V.O.R airborne navigational and landing aid, capable of receiving (*a*) any one of 100 channels in the I.C.A.O. navigational frequency band 108–117·9 mc/s.; (*b*) any 20 spot frequencies in the I.C.A.O. navigational frequency band 329·6–335 mc/s. allocated for the glide path portion of the I.L.S. (instrument landing system); (*c*) 75 mc/s, the frequency allocated for the marker beacon.

New U.H.F. radio telecommunications equipment was shown by the Plessey Company Limited, Ilford, Essex, providing 1,750 channels and designed to supplement the existing V.H.F. network, and available in single and multi-channel forms.

TUBES AND TRANSISTORS

Among a variety of new electronic components displayed by Mullard Limited, Century House, Shaftesbury-avenue, London, W.C.2, was a 5 in. high-brightness radar tube, developed for use at high altitudes where the extremely high ambient light level precludes the use of previously available radar tubes owing to insufficient raster brightness.

Mullard was also one of the firms demonstrating how the application of transistors can result in spectacular weight and space savings. A transistorised portable loud hailer was shown, comprising essentially a megaphone of normal dimensions equipped with batteries, a microphone, an amplifier using junction transistors, and a loud-speaker. Speaking into the instrument at normal voice level produces an output loud enough for use in hangars and on airfields. Transistors are also employed in the experimental decade counter exhibited by Mullard, which has a maximum counting speed of 100,000 per second with a resolution time of 10 microseconds, and consumes 100 mA at 6 volts.

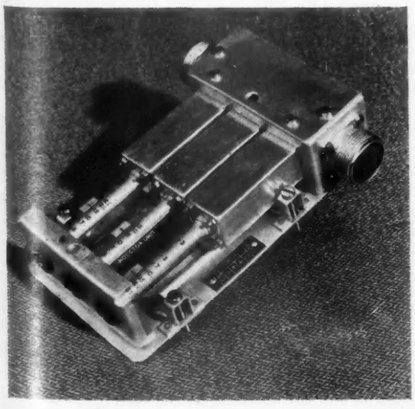


Fig. 24 The quadrantal error corrector unit of the AD 22 sub-miniature automatic direction finder.

STARTING AND STOPPING

Lightweight mono-fuel turbo-starters which require no air supply and which, consuming little current, can be started on the aircraft batteries are now being adopted by the Royal Air Force for military aircraft. Starters of this type employing iso-propyl-nitrate (I.P.N.) as fuel were shown by Rotax Limited, London, N.W.10, by the Plessey Company, Limited, Ilford, Essex, and by the British Thomson-Houston Company, Limited, Rugby. The B.T.H. system has recently been ordered by the Ministry of Supply for installation on Gloster Javelin aircraft; it is claimed to be some 30 per cent. lighter than previous starting systems, and requires a starting current of less than one ampere. It is shown in Fig. 25.

To the converse problem—that of bringing a heavy, high-speed aircraft to rest after touch-down—Dowty Equipment Limited, Cheltenham, have introduced and showed, at Farnborough, a completely new technique that is still under development. The Dowty runway brake is an attempt to overcome the problem of disposing of the heat generated during braking by using the runway surface itself as one of the braking surfaces, the other comprising flat synthetic-rubber pads incorporated in the main under-carriage units. During the landing run the pad assembly is lowered on to the runway, partially unloading the main wheels. For taxying the pads are retracted; they can also be used, fully extended, to jack the aircraft off the runway for wheel changing.

Another brake development, for helicopters, was shown by Palmer Tyre Limited, Herga House, Vincent-square, London, S.W.1, comprising a compensator to overcome the problem of resonance at certain critical speeds of the rotor when the aircraft is braked. The compensator consists essentially of two spring units connecting the front of the leg to the front of the brake and the rear of the leg to the rear of the brake, the brake attachment points being horizontally opposite. When the brake is applied and the brake frame is subjected to alternating axial torque it is free to oscillate to the same degree of angular movement and at the same rate as the lateral oscillation. Therefore, as the leg and tyre assembly can oscillate in any direction with the same amplitude and the same frequency out-of-phase to the rotors, there is no tendency to resonance. To prevent overload on the units, they become solid connectors at the end of their travel.

ALTERNATORS, MOTORS AND MAGNETS

The increasing use of alternating current electrical systems was emphasised by the static exhibits of the Aircraft Equipment Division of the English Electric Company, Limited, who showed a sectioned Sundstrand constant-speed drive (described in ENGINEERING, February 18, page 215) with a Type 918 40-kVA alternator. The latter machine has been designed primarily for use with the Sundstrand drive (the purpose of which is to convert the wide range of engine input speeds to the constant speed required by the alternator). It provides an output frequency of 400 cycles constant to $\pm$ 1 per cent. The type 918 alternator contains a built-in six-pole exciter and is equipped with brushes suitable for high-altitude operation. It is blast cooled at the rate of 180 cub. ft. of air per minute at 6 in. water gauge pressure. The alternator weighs 98 lb. and the Sundstrand drive 78 lb.

A turbo-alternator was featured on the stand of Sir George Godfrey and Partners, Limited, Hanworth, Middlesex, who are perhaps more usually associated with cabin pressurising and air-conditioning equipment, both airborne and in the form of ground servicing trolleys.

The Godfrey TA-15 turbo-alternator is a direct-coupled unit in which the turbine wheel and the alternator rotor are mounted on a common shaft. The alternator, designed and manufactured by Rotax, Limited, has a rated output of 15 kVA at 208 V (at the terminals), and 400 cycles all altitudes up to 60,000 ft.

The frequency is controlled to a constant 400 cycles by an electronic controller operating, through a hydraulic servo, variable-area nozzles in the turbine. The alternator casing is pressure-ised, the air within the casing being circulated through the alternator by a fan mounted on the rotor shaft. The heat absorbed by the circulating air is rejected to the fuel in an annular fuel-to-air heat exchanger which surrounds the alternator.

Oil for lubricating the bearings and for operating the hydraulic servo is obtained from a Barske-type oil pump driven through spiral bevel gears at 24,000 r.p.m. from the main shaft. Protection against overspeeding is provided by a mechanical governor which closes a shut-off valve in the entry to the turbine volute. The unit, complete with frequency control equipment, weighs 120 lb. and only requires air to the turbine and fuel to the heat exchanger to operate it.

Another turbo-alternator, in this case a small unit for use as an airborne auxiliary generating plant, was shown by the British Thomson-Houston Company, Limited, Rugby. The gas turbine driving the alternator is a development of the automobile gas turbine designed by the Rover company. The air supply to the gas turbine also ventilates the alternator.

Small high-frequency sub-synchronous motors of simple construction suitable for expendable purposes were shown by Short Brothers and Harland, Limited, Belfast. The magnetic circuits of these motors are made of solid blocks of ferrite material which can be moulded, or machined using a standard 50 watt Mullard ultrasonic drilling machine. In addition to being easily and cheaply manufactured, the magnetic ferrite material shows a complete absence of eddy-current losses, is non-conducting and is lighter in weight than magnetic iron. Fig. 26 shows a 2,400-cycle fan motor, a

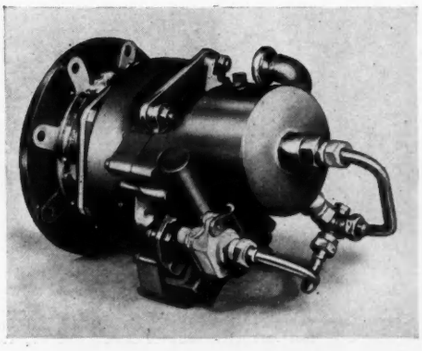


Fig. 25 Iso-propyl-nitrate turbo-starter. The British Thomson-Houston Company, Limited.

Fig. 26 Sub-synchronous motors and ferrite components used in their construction. Short Brothers and Harland, Limited.

sub-synchronous motor, and some of the ferrite components used in their construction.

PLASTICS PRESSURE VESSELS: 3,000 LB. PER SQ. IN.

Resin-impregnated Fibreglass pressure vessels, of spherical form, have been developed by Rotax, Limited, London, N.W.10, the Dunlop Rubber Company, Limited, Coventry, and the Walter Kidde Company, Limited, Northolt, Middlesex, for use in aircraft pneumatic systems. Vessels of this kind are illustrated in Fig. 27. Those exhibited by Dunlop were of 550 and 900 cub. in. capacity, designed for a working pressure of 3,300 lb. per square inch; the 550 cub. in. sphere weighs 16 lb.—about 10 lb. less than an aluminium-alloy vessel for the same duty.

The Kidde air pressure containers are designed for a working pressure of 3,000 lb. per square inch, and are available in four sizes—125, 650, 900, and 1,300 cub, in., with corresponding weights of 2¼ lb. 11 lb., 16 lb. and 22 lb. Tests have shown that these vessels can satisfactorily withstand 20,000 cycles of loading to full working pressure.

In addition to their high strength-to-weight ratio, resin-impregnated Fibreglass pressure vessels offer high impact resistance, dimensional stability, and resistance to weather, temperature and chemical attack.

EXPLOSION SUPPRESSION

For some years now the Graviner Manufacturing Company, Limited, Colnbrook, have been working on explosion-suppression systems, and their industrial applications have been described in ENGINEERING. At Farnborough they showed the equipment that they have developed for military aircraft and which has now been adopted for installation in operational aircraft. Installed in aircraft tanks, it has been tested with complete success under a stream of incendiary bullets. The detector is of the photo-electric cell type, responding within one millisecond to the flash as a bullet enters the tank, and actuating a cylindrical suppressor from which a spray of extinguishing fluid is ejected.

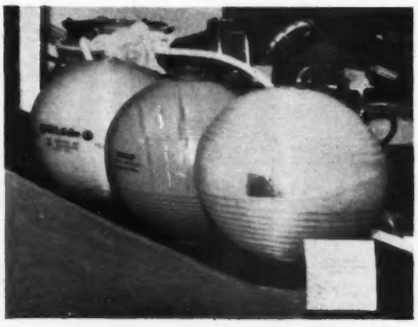


Fig. 27 Resin-impregnated glass fibre pressure vessels by Kidde, Dunlop and Rotax.

The original explosion suppression scheme emanated from the Royal Aircraft Establishment and, it may be recalled, operated in response to rate of rise of pressure within the tank; for military aircraft engaging in manoeuvres, this form of detection proved not to be satisfactory; the photocell detector now employed is unaffected by manoeuvres and also responds more rapidly. Originally, also, a hemispherical suppressor was employed; the cylindrical form now used for aircraft applications has proved to be more easily installed in flexible tanks.

MISCELLANEOUS

Other interesting engineering features seen at Farnborough include the diagrammatic display of the electronic control of machine tools by Ferranti Limited, in which information on the shape of the part is fed by tape into the machine's computer, which translates it into the required tool movements and sets these in motion; a heavy-duty balancing machine for gas-turbine rotors, etc., weighing from 75 to 1,500 lb., which enables forces displacing the centre of gravity by amounts ranging from 0·00002 and 0·06 in. to be quickly and precisely measured, shown by Electric and Musical Industries, Limited, Hayes, Middlesex. This company also showed a heavy-duty electro-magnetic vibrator (Fig. 28), entirely free from resonance throughout its working range, and with negligible harmonic distortion, giving 2,000 lb. thrust and an excursion of 1 in. at frequencies up to 1,000 cycles. The first British ram-air turbine designed for emergency power supply for the essential flying controls, was exhibited by the Plessey Company, Limited, Ilford. It is normally retracted but automatically swings out into the airstream if the normal hydraulic power supply fails.

In conclusion, we would say once again that this article is in the nature of a lucky dip into Farnborough's bran tub, rather than a detailed survey.

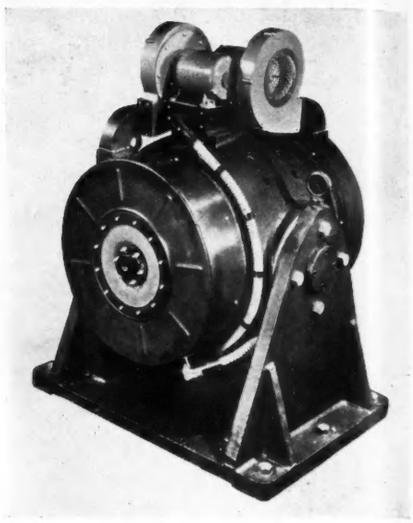


Fig. 28 Heavy-duty vibrator. Electric and Musical Industries, Limited.

SERVO UNIT FOR KINETIC HEATING RIG

Excitrons Give Quick Response, Light Ripple

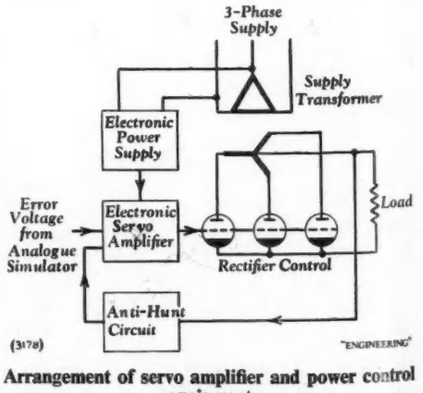
As noted on page 471, the structures department of the Royal Aircraft Establishment are developing an automatically-controlled test rig for introducing the appropriate kinetic heating effects into strength tests on a high-speed aircraft structure. The problem of supplying and controlling the relatively large power to the bank of infra-red lamps used for heating the test specimen is carried out by servo amplifier and power rectifier equipment supplied by the English Electric Company, Limited, Marconi House, Strand, London, W.C.2.

The choice of rectifier power equipment was governed by the following factors: (*a*) the response of the control system has to be rapid to enable quick changes in heat intensity to be made; grid-controlled rectifiers will respond more rapidly than any other system operating at the same frequency; (*b*) the light ripple due to the supply mains must be kept to a minimum to avoid trouble with photo-electric detection, and smoothing of signals therefrom; although pure direct-current control would be preferable here, the 150 cycle ripple voltage from the three-phase rectifiers is considerably superior to 50 cycle alternating-current control; (*c*) when considering a large number of these units, as will ultimately be required, floor space will be at a premium. Rectifier equipment utilising a common supply-transformer can exploit height more favourably than other conversion equipment.

The rectifiers used are the single-anode type with mercury-pool cathodes known as "excitrons." Three such valves form a three-phase half-wave system when supplied from a star-connected transformer (see illustration below).

Direct-current output up to 50 kW at 500 volts can be obtained to feed the bank of infra-red lamps. Each valve is fitted with its own starting electrode which also serves as the excitation anode after the arc has been ignited. Control of the main anode discharge is achieved with a "grid" in the normal manner. An infinitely variable output is then obtained from maximum power down to 100 watts or lower.

This range of power output is controlled from the error voltage of an analogue simulator



Arrangement of servo amplifier and power control equipment.

through an electronic amplifier (as shown). A closed-loop control system is so formed to adjust automatically the heat intensity of the lamps to the demands of the simulator. The amplifier has two stages of direct-current amplification followed by a power amplifier feeding the grid control circuits of each rectifying valve. The gain of the system is adjusted so that an input signal of a few micro-watts is capable of controlling the full power output. A signal from the lamp circuit is fed back to the input of the amplifier to prevent instability of the system.

The power supply to the amplifier has to be as steady as possible to avoid drift and changes in gain. A valve-stabilised supply is used consisting of the conventional rectifier and smoothing circuits followed by a series-regulating valve controlled from a high-accuracy neon reference circuit.

The whole equipment excluding the supply transformer is housed in a 2 ft. square cubicle (illustrated in Fig. 22, on page 472). with a height of approximately 6 ft. The floor space occupied is then approximately equal to the total surface area of the heating load itself.

INSTITUTE OF METALS AUTUMN MEETING

DEVELOPMENT OF RESEARCH TECHNIQUES

The 47th annual autumn meeting of the Institute of Metals was held in Buxton, from Monday, September 19, to Friday, September 23, by invitation of the Sheffield local section of the Institute and the industries of South Yorkshire. The meeting opened on the afternoon of the first day when two simultaneous scientific sessions were held. These and subsequent technical sessions will be dealt with in forthcoming issues. We now give a brief report of a meeting held in the Firth Hall of the University of Sheffield on the morning of Tuesday, September 20.

The chair at the meeting was taken by the President of the Institute, Dr. Maurice Cook, who welcomed the members and delegates from overseas.

ELECTION OF MEMBERS AND COUNCIL

The secretary announced that since the last general meeting of the Institute 148 new members had been elected and that the total active membership was 4,385.

He also announced that, as required by the Articles of Association, the following officers and members would retire from the Council at the annual general meeting in April, 1956, namely, as President, Dr. Maurice Cook, as past-President, Dr. C. J. Smithells, M.C., as vice-Presidents, Major C. J. P. Ball, D.S.O., M.C., and Professor G. V. Raynor, and as members of Council, Mr. Alfred Baer, Mr. N. I. Bond-Williams, Dr. N. P. Inglis, Dr. Ivor Jenkins, Dr. A. G. Ramsay and Dr. H. Sutton, C.B.E.

In accordance with the Articles of the Institute, Dr. Maurice Cook would fill the vacancy on the Council as past-President and the Council had nominated the following members to fill the other vacancies: as President, Major C. J. P. Ball; as vice-Presidents, Dr. N. P. Inglis and Dr. Ivor Jenkins, and as members of Council, Mr. G. L. Bailey, C.B.E., Mr. J. W. Berry, Mr. G. E. Dono, J.P., Dr. H. M. Finniston, Professor Hugh Ford, and Mr. C. H. M. Holden.

Moreover, the Council had elected Dr. L. B. Pfeil, O.B.E., F.R.S., to serve as senior vice-president for 1956-57 and he would be their nominee for the Presidency in 1957-58.

The secretary's last announcement was that next year's annual autumn meeting would be held in Stuttgart at the invitation of the Deutsche Gesellschaft für Metallkunde.

DEVELOPMENT OF RESEARCH TECHNIQUES

At the conclusion of the business the President called upon Dr. C. Sykes, F.R.S., managing director of Thomas Firth and John Brown, Limited, Sheffield, to deliver the 26th Autumn Lecture of the Institute. Dr. Sykes, who had chosen as his subject "The Development and Improvement of Research Techniques," stated that the Institute had last met for its Autumn Meeting in Sheffield in 1937 and he proposed to compare the techniques available at the present time for metallurgical research with those in being in 1937.

Taking first the subject of chemical analysis, this at the present time, said Dr. Sykes, was supplemented by apparatus employing physical and physical-chemical principles. The photo-electric absorptiometer and the spectrophotometer enabled analyses of all the elements in irons and steels, apart from carbon and sulphur, to be determined readily and speedily. In recent years by means of chromatography it had been possible to separate such elements as niobium and tantalum, which separation had proved very difficult by ordinary methods. Latterly, the production-control Quantometer, a direct-reading instrument enabled metals and other inorganic materials to be analysed quickly and accurately. These and other similar developments had freed steelwork laboratories from much of the laborious work of analysis by the older time-honoured methods.

In the field of metalurgical microscopes, much had been accomplished in the past 20 years. The incident light phase microscope was proving a useful tool in the hands of the metallographer while by the use of the flying-spot microscope, fields of view could be rapidly scanned by means of a spot of light. Great improvements had also been realised in the preparation of specimens and electrolytic and similar etching methods were now in regular use. Among the latest developments in high-power metallography was electron microscopy in which the repliqua technique was employed.

The X-ray diffraction technique for the examination of structures had developed steadily and the scope of the methods now used was very extensive indeed.

Another process perfected in recent years, by which extremely pure metals could be obtained was that of zone melting. By means of this method, the copper and zinc present in an aluminium of 99·95 per cent. purity could be practically eliminated from the parent metal.

Much progress had been made in the field of direct immersion pyrometry, for the determination of liquid-steel temperatures, and instruments of this type were now in regular use in steelworks melting shops.

Such procedures as the Jominy end-quenching test enabled the hardenability of whole series of alloys to be determined quickly and effectively, while it was of interest to note that practically the whole of the extensive creep data on steels and other alloys now on record, had been determined during the past 20 odd years.

Finally very great strides had been made in recent years in such non-destructive methods of testing castings and forgings as the gamma-ray and ultrasonic techniques. The thickness of the metal which could be scanned by these methods had been greatly increased and they had contributed materially to the improvement of the quality of heavy engineering components.

WORKS VISITS

After luncheon at the Royal Victoria Hotel, Sheffield, at the invitation of the reception committee for the meeting and the industries of Sheffield and district, at which the Lord Mayor of Sheffield, Alderman J. Curtis, welcomed the guests and the President, Dr. Maurice Cook, responded, the members left by motor coach to visit various works and other technical establishments in Sheffield and its vicinity. These comprised, Edgar Allen and Company Limited, Imperial Steel Works, Sheffield; the British Iron and Steel Research Association, Research Laboratories, Hoyle-street, Sheffield; the Chesterfield Tube Company Limited, Derby-road, Chesterfield; Davy and United Engineering Company Limited, Park Iron Works, Sheffield; Firth-Brown Tools Limited, Speedicut Works, Sheffield; Millspaugh Limited, Alsing-road, Sheffield and Walker and Hall Limited, Electro Works, Sheffield.

The whole of Wednesday, September 21, was devoted to visits to the works of Thomas Bolton and Sons, Limited, Froghall, Staffordshire; the David Brown Companies, Limited, Penistone, near Sheffield; the English Steel Corporation, Limited, River Don Works, Sheffield; Thos. Firth and John Brown, Limited, Atlas Works, Sheffield; Firth-Vickers, Limited, Sheepcote Lane Works, Sheffield; Hadfields Limited, East Hecla Works, Sheffield; and the Steel, Peech and Tozer Templeborough Works and the Swinden Laboratories of the United Steel Companies, Limited, Rotherham.

FINANCIAL SUPPORT FROM OVERSEAS

On the morning of September 22, an extraordinary general meeting was held in Buxton for the purpose of considering and, if thought fit, passing a special resolution regarding the creation of a new class of members, namely overseas sustaining members. These involved corporate bodies, having their headquarters or principal places of business outside the United Kingdom, which would desire to give financial support to the objects and work of the Institute. An overseas sustaining member would be entitled to nominate not more than two individuals for membership of the Institute. Unless and until otherwise determined by the Council, each overseas sustaining member would pay a minimum annual subscription of £25.

As explained by the secretary, the new class of member would provide means whereby companies from outside the United Kingdom could support the Institute in a manner in which companies inside the United Kingdom were already doing.

The special resolution was put by the President, Dr. Maurice Cook, seconded by Major C. J. P. Ball, and carried by the meeting.

THE PLATINUM MEDAL

After the conclusion of the extraordinary general meeting the Institute of Metals Platinum Medal for 1955 was presented to Dr. C. J. Smithells, M.C. In doing so, Dr. Cook said that this, the highest award which it was in the Council's power to confer, had been bestowed upon Dr. Smithells for the services he had rendered to metallurgical science to the metallurgical industry and to the metallurgical profession.

To be continued

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ELECTRICITY SUPPLY IN AUGUST

During August, 1955, 4,411 million kWh were sold by the Central Electricity Authority to the English and Welsh Area Boards. This was an increase of 5·1 per cent. over the figure for August, 1954. When corrected for weather conditions and working days the increase was, however, 10·5 per cent.

The amount of electricity sent out by the Area Boards during the same month was also 4,411 million kWh, of which 153 million kWh were supplied directly by the Central Authority. The increases in the amounts sent out, compared with the figures in 1954, were 4·8 per cent. in the "mainly industrial" and 2·8 per cent. in the "mainly non-industrial" areas.

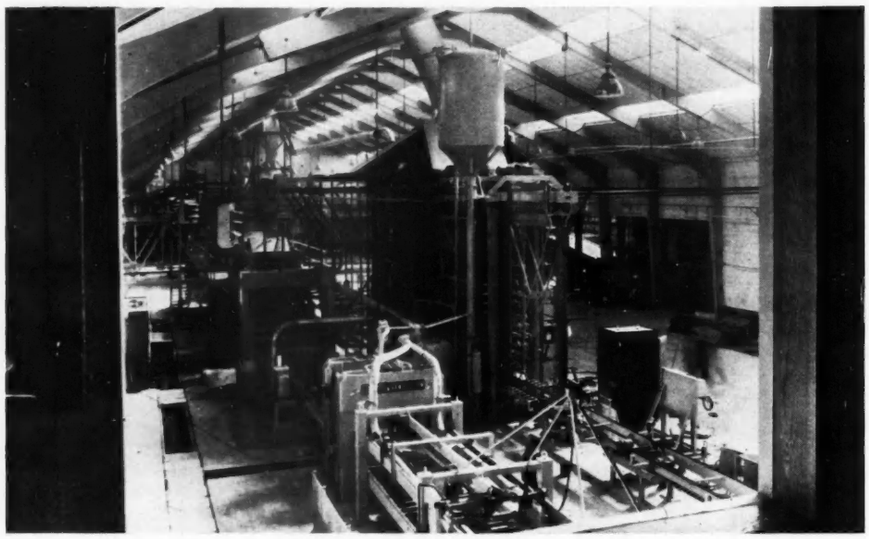


Fig. 1 A continuous process for the production of chipboard from logs 1½ in. to 9 in. in diameter gives a yield of about 100 boards 8 ft. by 4 ft. by ¾ in. thick every hour.

CONTROLLED QUALITY CHIPBOARD

FORESTRY THINNINGS USED IN NEW SCOTTISH FACTORY

The official opening of the chipboard factory built by the Airscrew Company and Jicwood, Limited, at Annan, Dumfriesshire, was by His Grace the Duke of Buccleuch and Queensbury, P.C., K.T., G.C.V.O., on September 28. Estimates of the production capacity from the continuous process used are 100 boards an hour, the finished size of a board being 8 ft. by 4 ft. by ¾ in. thick.

The material used in this process will be the thinnings from the State forests of the neighbourhood. This will give an even level of quality of raw material which, it is claimed, will enable a strong lightweight board of graded density to be produced. The product will be known as Gold Label Weyroc, and will have a fine-textured dense surface and an inner layer of coarser formation. The board can be produced to fine dimensional tolerances and the surface is suitable for high-grade veneering. It has a high resistance to water absorption.

The factory covers an area of approximately 46,000 sq. ft., and the flow line is continuous under a roof span of 85 ft. The rough logs, conifers from 1½ in. to 9 in. in diameter, are brought from the forests and stacked in the receiving yard. Here they are cut into standard lengths and then fed by a conveyor to the peeling shed. This is a building separated from the main factory, and in it the bark is removed as shown in Fig. 2 and the logs finished roughly cylindrical to ease later handling. Specially developed machines are used to cater for the various types of raw material likely to be received, and at this stage any useful wood removed with the bark is separated and returned to the main flow line thus avoiding waste. From the peeling station standard-length peeled logs are mechanically handled to the main 1,000 ton stock pile.

The first process in the production line itself is the breaking up of the logs into chips. From the stock pile, the logs are conveyed mechanically to two machines, one of which makes chips suitable for the surface and the other the coarser chips for the interior. From here on there are two flow lines for the different materials. Like most of the plant the chipping machines are particularly designed for the job and, in conjunction with pneumatic conveying, milling and sifting equipment, permit the production of any desired type of wood chip. This factor is most important in governing the properties of the finished board, and the flexibility possible at this stage of the production process gives great scope for varying the end product. Thus boards of one type of chip throughout with uniform density from face to face, boards of one type of chip but with density graded from maximum at the faces to minimum at the centre, or boards with chips progressively changing from fine at the surface to coarse at the centre with almost any density gradient from surface to centre can be produced at will.

After this stage surge bunkers are incorporated in the production lines so that a two or three-hour supply of chips is available to maintain continuous production should a stoppage occur on any of the equipment prior to the bunkers. Material passes through the bunkers in strict rotation to avoid stagnant pockets, and a metering device at the outlet end provides a stabilised feed to the dryers which follow.

So that accurate control of the moisture content of the boards can be maintained, the chips are dried to a very low and uniform moisture content, the driers being designed so that they form part of the general conveying system between chip production and later stages. The dryers are of the hot-air, cross-flow type and are fully insulated. In order to achieve maximum efficiency the drying air is exhausted only when it is virtually saturated and incapable of carrying more moisture.

After having been fully dried, the chips pass by pneumatic conveyor to the next stage, which consists of the introduction of the required amount of resin for bonding, and of its thorough mixing with the chips. Since the quantity and disposition of the resin affects the nature of the finished board a system is used which gives automatic control of the amount added.

As chips flow from the dryer a continuous record is taken of the rate of flow, and from this record a signal is derived to control the amount of resin flowing to the mixer, where the resin is sprayed on to the chips as a fine mist. The time taken for chips to be conveyed from the weigher to the mixer is allowed for by a delay in the control system thus, for example, a fluctuation of dryer output giving a momentary increase of 5 per cent. in the flow rate of chips will give a corresponding momentary increase of 5 per cent. in resin flow when those chips are flowing through the mixer.

The proportion of resin to chips can at any time be varied simply by turning a knob on the controller, and a visible permanent record is always available of the resin and chip flows and proportions. As the process at the mixing stage is still divided into two separate flow lines, accurate control of resin distribution throughout the thickness of the board is available to achieve maximum strength, quality and economy.

The mixing of the resin solution to be added to the chips is a complicated process. Several ingredients are introduced to the resin, some to confer water resistance to the boards, others to eliminate fumes during and after manufacture, or to obtain fast curing, etc., and all these ingredients are measured and mixed automatically thus avoiding the possibility of human error and maintaining consistency of finished product.

At this stage more surge bunkers, similar in function to those before the dryers, are incorporated in the production lines so that an inadvertent stoppage of dryers, weighers or mixers will not interrupt the continuous operation of the spreading station which follows.

In the next operation, that of building up the boards by layers, the two flow lines come together again in the spreading machine which deposits the mixture of chips and resin on a continuous moving line of metal plates, end to end, each plate being slightly larger than the finished board size. The spreading machine is arranged to deposit any required thickness of "mattress" to suit the thickness and density of board and, at the same time, to distribute the fine and coarse chips in their correct relative positions. Thus the first operation lays the lower surface of fine chips, then follow the coarse

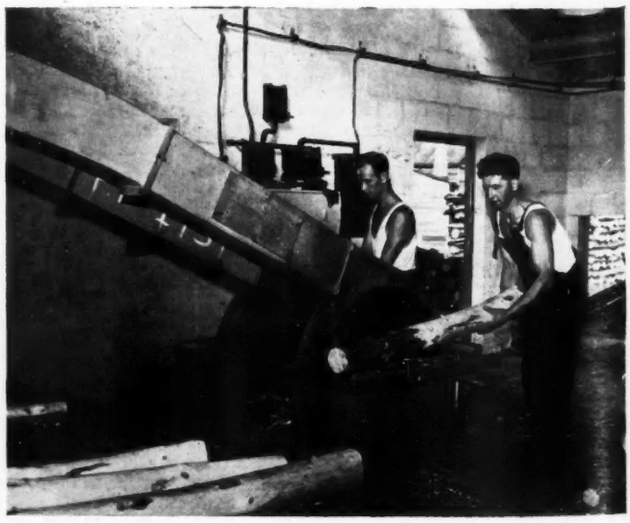


Fig. 2 The first operation after cutting to length is the removal of bark from the logs, making them roughly cylindrical.

chips forming the heart of the board and then another layer of fine chips to form the second surface. Associated with the spreader is a trimming saw which parts the continuously formed mattress into board lengths, each separate mattress thus formed being carried by one of the metal plates. Also associated with the spreader is a weighing station to provide a constant check on spreader output by indicating the weight of each mattress.

The mattresses so formed then pass automatically into a press where partial consolidation occurs. As the mattresses leave the press and pass along the conveyor, the sides are trimmed to width. The final press takes 15 mattresses at each loading and is fed by a special loader which takes the continuous stream of mattesses and stacks them ready for charging. The platens of the press are steam heated and hydraulically operated, having a maximum loading of 1,000 tons. Unloading is also automatic and occurs at the same time as loading. There is therefore no break in the flow line as a result of the time required for curing and pressing. After removal from the press, the metal plates are removed automatically from the boards and are returned by conveyor back to the spreader station. The rate of closing, the temperature, curing period and pressure are all adjustable, and are chosen to produce the required final properties.

After their ejection from the production line, the boards are placed for approximately a week in a maturing store where controlled cooling and stabilisation of moisture content and dimensions take place. From this store the boards in a completely stable condition are passed through saws, where edges are trimmed to give final dimensions of 8 ft. by 4 ft. Immediately following this operation both faces of the board are ground simultaneously on a multidrum sanding machine to give the final thickness of ⅜ in., and to give a smooth unbroken surface each side. After grinding, the boards are mechanically handled to the finished board store or taken direct to the dispatch bay.

* * *

HAND-OPERATED LIFT TRUCK

The most recent addition to the range of hand-operated lifting trucks made by Salisbury Precision Engineering Limited, Old Sarum Works, Castle-road, Salisbury, is shown in the illustration below. With a maximum lift of 42 in., it can raise a load of 780 lb. to a height of 45 in.

Built from steel plate and channel sections, the frame is carried on two 10 in. diameter main wheels and three casters which have solid cushion rubber tyres. The truck can be moved from place to place like a porter's barrow and manoeuvred as easily. The pump is operated by the vertical lever which can be seen at the rear, and is double-acting in operation with two speeds of lift. This enables the forks to be raised quickly when unloaded, or when carrying only a light load. The forks themselves are 23 in. long and can be spaced at distances of 13½ in. or 24 in apart. The overall width of the truck is 33 in. A platform can be supplied for fitting to the forks.

The latest addition to the "Sherpa" range of lift trucks has a capacity of 780 lb. The two-speed pump will give a maximum lift of 42 in.

* * *

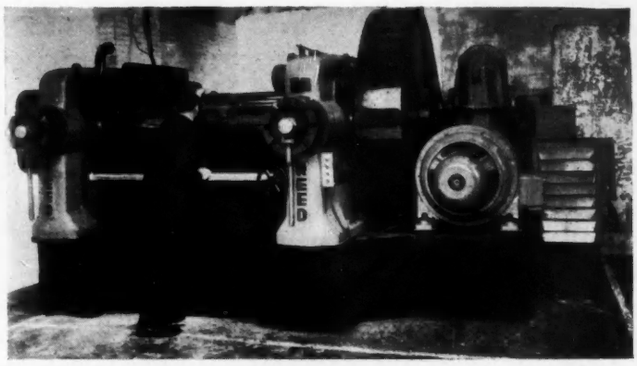
AN INTEGRAL TRACTOR SHOVEL

An addition to the range of equipment produced by the Caterpillar Tractor Company, Limited, Mantle-lane, Coalville, Leicestershire, is the 955 Traxcavator, which is an integral tractor-shovel machine. It is shown in the illustration on the right.

The bucket has a capacity of 1½ cub. yards and can be tilted through an angle of 40 deg. At ground level the push and upward thrust motions can be operated simultaneously, and the bucket can be tilted and levelled during the push so that it can work into the material with greater ease. Tilting the loaded bucket backwards the full 40 deg. moves the centre of gravity so that the weight is transferred to the arm action and is not concentrated on the bucket linkage.

The tractor portion of the machine includes many parts common to the D4 tractor. The oil-type flywheel clutch may be removed without disturbing either engine or transmission. A full-flow filter has been fitted in the hydraulic system, and the actuating cylinders are mounted above the tracks to keep them clear of mud and rocks. Either a direct starting 24 volt system can be fitted or, alternatively, there can be a starting engine operating from a six-volt system. The main engine is rated at 70 h.p., and there are four forward and two reverse speeds. The weight of the complete machine is 21,480 lb., the length 15 ft. 1½ in., width 6 ft. 8 in. and height 6 ft. 10⅛ in. The ground clearance is 1 ft. 1½ in.

The 1½ cub. yard bucket on the 955 Traxcavator can be tilted back through an angle of 40 deg.



This 60 in. by 22 in. rubber and plastics mill is driven by a 100 h.p. motor, needs no foundations other than its own bedplate, and has the safety bar arranged so that the operator can easily see the whole of the inside of the tray.

RUBBER AND PLASTICS MILL

Easier Working with Equal Safety

A bedplate which acts as a foundation and safety arrangements permitting easier working are the two main features of a 60 in. by 22 in. rubber and plastics mill recently produced by Reed Brothers (Engineering) Limited, Cuba-street, London, E.14. The mill, shown in the accompanying illustration, weighs 26 tons and is mounted on a fabricated bedplate fitted with "vibro-insulators," made by the British Tyre and Rubber Company, Limited, Herga House, Vincent-square, London, S.W.1. The bedplate acts as a portable foundation for the mill and a 4 in. concrete floor gives adequate support. Surface inequalities of the floor do not matter as the jacking screws of the vibro-insulators are adjusted when the mill is in position to bring the rolls level. Overall dimensions are 19 ft. long by 11 ft. 2 in. wide by 7 ft. 2 in. high.

The drive is from a 100 h.p. Brook screen protected slip-ring motor by flexible coupling to a Holroyd 20 in. underdriven worm reduction gear with an extended output shaft. A forged steel machine-cut pinion mounted on this shaft drives the large bull wheel on the back roll which has a surface speed of approximately 70 ft. per minute.

The Lunn-principle sensitive safety bars, clearly shown in the illustration, are mounted 42 in. above floor level. The crown height of the rolls is 63 in., and as can be seen the design is such that the operator works in safety but can see the whole of the inside of the tray clearly. The safety bar operates robust industrial limit switches which are linked with the control circuit of the special plug braking equipment. Control is by push buttons with "start," "stop" and "inch reverse" stations. An indicator light shows when the motor is running at full speed to avoid accidental overloading.

On depressing the start button the forward stator contactor is brought in and as the motor comes up to speed steps of rotor resistance are cut out in sequence controlled by dash pots. As soon as the sensitive safety bar is moved the forward stator contactor falls out, the full rotor resistance is put back in circuit, and the reverse contactor comes in and remains in until the motor stops. In this way the mill is stopped when running light in less than ⅛ revolution of the front roll. The mill is equally suitable for rubber and plastics, but for plastics water-cooled bearings are fitted.

FORTHCOMING EXHIBITIONS AND CONFERENCES

This, arranged chronologically, list appears in the last issue of each month. Events appearing for the first time, and alterations of dates, places, etc., are indicated by an asterisk (*). Particulars of exhibitions and conferences not included below may have appeared in ENGINEERING, *July 29, page 159; or August 26, page 287. Organisers are invited to send to the Editor particulars of events as soon as arrangements are made.*

***Czechoslovak Engineering Exhibition.**—Sun., Sept. 11, to Sun., Oct. 9, at Brno, Czechoslovakia. Organised by the Chamber of Commerce of Czechoslovakia, Rjna 13, Prague. Information obtainable from the Czechoslovak Commercial Attaché, 6 Upper Belgrave-street, London, S.W.1. Tel. SLOane 0691.

***Textile Machinery, Cotton, Rayon and Chemistry Exhibition.**—Sat., Sept. 24, to Sun., Oct. 9, at Busto Arsizio. Organised by the Mostra del Cotone e del Rayon, Via Mameli 2, Busto Arsizio, Italy.

***"' Minibition " and Purchasing Officers' Association's National Conference.**—Thurs., Sept. 29, to Sat., Oct. 1, at the Winter Gardens, Cliftonville. Organised by the Purchasing Officers' Association, 146A Queen Victoria-street, London, E.C.4. Tel. CITy 3841.

All-British Trade Fair.—Thurs., Sept. 29, to Sun., Oct. 16, in the Tivoli Gardens and the Forum, Copenhagen, Denmark. Inquiries to the British Overseas Fairs, Ltd., 21 Tothill-street, London, S.W.1. Tel. WHItehall 6711. See ENGINEERING, July 16, 1954, page 69.

***Nautical Exhibition, 20th International**—Fri., Sept. 30, Sun., Oct. 16, in Paris. *Agents:* Auger and Turner Group Ltd., 40 Gerrard-street, London, W.1. Tel. GERrard 6671.

Royal Agricultural Show.—Sat., Oct. 1, to Thurs., Oct. 6, at Claremont, Western Australia. Organised by the Royal Agricultural Society of Western Australia, 9 Howard-street, Perth.

***Radio, Television and Electronics Exhibition.**—Sat., Oct. 1, to Tues., Oct. 11, in Paris. Organised by the Salon de la Radio, de la Télévision et de l'Electronique, 23 Rue du Lubeck, Paris 16e.

***Radio Exhibition.**—Sat., Oct. 1, to Sun., Oct 16, at Brussels. Organised by the Comité des Expositions de la Radio-Electricité et Industries Connexes, 100 Boulevard Louis Schmidt, Brussels.

***Brussels Colonial Exhibition, Eighth.**—Sat., Oct. 1, to Sun., Oct. 16, at Brussels. Apply to the director, Foire Coloniale de Bruxelles, 20-21 Boulevard Baudouin, Brussels.

Automatic Control in the Process Industries, Conference.—Tues., Oct. 4, at Church House, Great Smith-street, London, S.W.1. Under the joint organisation of the Society of Instrument Technology, and the Institution of Chemical Engineers, 56 Victoria-street, London, S.W.1. Tel. VICtoria 6161. See ENGINEERING, July 29, page 133.

***Motor and Cycle Show, 42nd International.**—Thurs., Oct. 6, to Sun., Oct. 16, in Paris. *Agent:* Mr. R. C. Liebman, 178 Fleet-street, London, E.C.4. Tel. CITy 5889.

German Plastics Industry.—Sat., Oct. 8, to Sun., Oct. 16, at Düsseldorf, Germany. Organised by the Nordwestdeutsche Ausstellungs-Gesellschaft m.b.H. (NOWEA), Ehrenhof 4, Düsseldorf. *Agents:* John E. Buck & Co., 47 Brewer-street, London, W.1. Tel. GERrard 7576.

Automotive Engineers, Society of.—*Aircraft Production Forum and Aircraft Engineering Display:* Tues., Oct. 11, to Sat., Oct. 15, at Los Angeles. *Transportation Meeting:* Mon., Oct. 31, to Wed., Nov. 2, at St. Louis, Miss. *Diesel Engine Meeting:* Wed., Nov. 2, to Fri., Nov. 4. Apply to the Society of Automotive Engineers, 29 West 39th-street, New York 18.

***Iron and Steel Institute, Special Meeting.**—Wed., Oct. 12, to Fri., Oct. 14, at Scunthorpe. Organised by the Institute, 4 Grosvenor-gardens, London, S.W.1. Tel. SLOane 0061.

Engineering Industries Association: London Regional Display.—Wed., Oct. 12, to Fri., Oct. 14, at Royal Horticultural Society's New Hall, Greycoat-street, London, S.W.1. Apply to the secretary of the Association, 9 Seymour-street, London, W.1. Tel.: WELbeck 2241.

Letterpress Methods Conference.—Wed., Oct. 12, to Sat., Oct. 15, at the Grand Hotel, Eastbourne. Arranged by the Printing, Packaging and Allied Trades Research Association, Patra House, Randalls-road, Leatherhead, Surrey. Tel. Leatherhead 4041.

***Fuel Efficiency Exhibition and Conference.**—Wed., Oct. 12, to Sat., Oct. 22, at City Hall, Manchester, under auspices of Combustion Engineering Association and National Industrial Fuel Efficiency Service. Organisers: Provincial Exhibitions, Ltd., City Hall, Deansgate, Manchester. Tel. Deansgate 6363. Thurs. and Fri., Oct. 13 and 14, conference arranged by the Combustion Engineering Association. See ENGINEERING, September 23, page 408.

***Materials Handling Exhibition, International.**—Wed., Oct. 12, to Mon., Oct. 24, at Oslo. Apply to the Studieselskapet for Norsk Industri, Munkedamsveien 53b, Oslo, Norway.

***Office Equipment, 6th International Exhibition.**—Fri., Oct. 14, to Tues., Oct. 25, at Parc des Expositions, Porte de Versailles, Paris. Organised by the Salon International de l'Equipement de Bureau, 6 Place de Valois, Paris 1er.

Metals Exposition, 37th National.—Mon., Oct. 17, to Fri., Oct. 21, at Philadelphia. Organised by the American Society for Metals, 7301 Euclid-avenue, Cleveland 3, Ohio, U.S.A.

Solid Fuels Conference.—Wed., Oct. 19, to Fri., Oct. 21, at Neil House, Columbus, Ohio. Organised jointly by American Society of Mechanical Engineers and American Institute of Mining and Metallurgical Engineers. Apply to conference offices, 1672 Barrington-road, Columbus 21, Ohio, U.S.A.

Motor Show (40th International Motor Exhibition).—Wed., Oct. 19, to Sat., Oct. 29, at Earl's Court, London, S.W.5. Organised by Society of Motor Manufacturers and Traders, Ltd., 148 Piccadilly, London, W.1. Tel. GROsvenor 4040.

Plant Engineers' Scottish Conference.—Fri., Oct. 21, to Sun., Oct. 23, at Dunblane Hydropathic Hotel, Perthshire. Organised by Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. Tel. Solihull 3021.

Canadian Industrial Tool and Equipment Show.—Mon., Oct. 24, to Fri., Oct. 28, at the Show Mart Building, Montreal. Inquiries to the show offices: 4585 Sherbrooke-street W., Montreal.

***Observation of Structures Conference.**—Mon., Oct. 24, to Fri., Oct. 28, at the Laboratório Nacional de Engenharia Civil, Av. do Brazil, Lisbon, Portugal. Organised by the Laboratory. Inquiries should be addressed to the acting director of the Laboratory.

***National Business Show.**—Mon., Oct. 24, to Fri., Oct. 28, in New York. Apply to the manager, National Business Show, 30 Vesey-street, New York 7.

***Industrial Accident Prevention Conference.**—Fri., Oct. 28, Guildhall, London, E.C.2. Organised by the London Industrial Co-ordinating Committee, with the co-operation of the Royal Society for the Prevention of Accidents, 38 Millbank, London, S.W.1. Tel. TATe Gallery 9196. Tickets, price 10*s.* 6*d.*, obtainable from Mr. H. Meanley, North Thames Gas Board, King's-road, Fulham, London, S.W.6.

Indian Industries Exhibition.—Sat., Oct. 29, to Thurs., Dec. 15, in Delhi. *Agents:* Auger and Turner Group Ltd., 40 Gerrard-street, London, W.1. Tel. GERrard 6671.

Belfast Business Efficiency Exhibition.—Mon., Oct. 31, to Sat., Nov. 5, at King's Hall, Belfast. Organised by the Office Appliance and Business Equipment Trades Association, 11-13 Dowgate-hill, London, E.C.4. Tel. CENtral 7771.

Impact of Science on Management in the Future, Conference.—Wed., Nov. 2, to Fri., Nov. 4, at Harrogate. Organised by the British Institute of Management, 8 Hill-street, London, W.1. Tel. GROsvenor 6000. See ENGINEERING, August 26, page 283.

Protective Equipment Conference.—Fri., Nov. 4, at the London School of Hygiene and Tropical Medicine, Keppel-street, London, W.C.1. Organised by the British Occupational Hygiene Society. Apply to Mr. D. Turner, Medical Research Council Laboratories, Holly-hill, London, N.W.3. See ENGINEERING, August 19, page 253.

Work Study Conference.—Fri. and Sat., Nov. 4 and 5, at St. Ermin's Hotel, Caxton-street, London, S.W.1, on "Aids to Effective Production Management." Organised in conjunction with Work Study Society by Society of Industrial Engineers, 28 Victoria-street, London, S.W.1.

***Arizona State Fair.**—Fri., Nov. 4, to Sun., Nov. 13, at Phoenix, Arizona, U.S.A. There is a United Kingdom Exhibit. Apply to the British Consulate General, 448 South Hill-street, Los Angeles 13, Calif., U.S.A.

***Bottling and Allied Industries Exhibition and Packing and Distributing Exhibition.**—Sat., Nov. 5, to Mon., Nov. 14, in Paris. *Agents:* General-Tours Agence Generale de Tourisme (U.K.), Ltd., 25 and 26 Park-lane, London, W.1. Tel. HYDe Park 6854.

***Dairy Equipment Exhibition, International.**—Sat., Nov. 5, to Mon., Nov. 14, in Paris. *Agents:* General-Tours Agence Generale de Tourisme (U.K.), Ltd., 25 and 26 Park-lane, London, W.1. Tel. HYDe Park 6854.

***Mechanical Handling Exhibition.**—Sat., Nov. 5, to Mon., Nov. 14, in Paris. Apply to the director, Salon de la Manutention, 40 Rue du Colisée, Paris 8e.

***Eastern Joint Computer Conference.**—Mon., Nov. 7, to Wed., Nov. 9, at the Hotel Statler, Boston, Mass., U.S.A. Apply to the organisers at that address.

***National Packaging Exposition, Fourth.**—Tues., Nov. 8, to Thurs., Nov. 10, at Toronto. Organised by the Packaging Association of Canada, 916 Yonge-street, Toronto, Canada.

Canada's Power Show.—Tues., Nov. 8, to Fri., Nov. 11, at the Show Mart Building, Montreal. Sponsored by the Institute of Power Engineers, 1176 Sherbrooke-street West, Montreal.

Metal-Phase Transformations Symposium.—Wed., Nov. 9, in London. Apply to the Institute of Metals, 4 Grosvenor-gardens, London, S.W.1. Tel. SLOane 6233. See ENGINEERING, December 3, 1954, page 723.

***Hotel and Allied Industries Equipment Exhibition.**—Thurs., Nov. 10, to Mon., Nov. 21, in Paris. *Agent:* Mr. R. C. Liebman, 178 Fleet-street, London, E.C.4. Tel. CITy 5889.

Royal Agricultural Winter Fair.—Fri., Nov. 11, to Sat., Nov. 19, at Toronto. Organised by the Royal Winter Fair Authorities, Royal Coliseum, Exhibition Park, Toronto 2B, Canada.

Scottish Motor Exhibition.—Fri., Nov. 11, to Sat., Nov. 19, at Glasgow. Organised by Scottish Motor Trade Association Ltd., 3 Palmerston-place, Edinburgh, 12. Tel. Central 3643.

Model Engineers' Exhibition, Ninth International.—Sat., Nov. 12, to Thurs., Dec. 15, at Bombay. Apply to Mr. M. P. Polson, Noble Chambers, Parsi Bazar-street, Fort, Bombay.

Cycle and Motor Cycle Show, 30th International.—Sat., Nov. 12, to Sat., Nov. 19, at Earl's Court, London, S.W.5. Organised by the British Cycle and Motor Cycle Manufacturers' and Traders' Union, Ltd., The Towers, Warwick-road, Coventry. Tel. Coventry 62511.

Automation Exposition, Second International.—Mon., Nov. 14, to Thurs., Nov. 17, at the Navy Pier, Chicago. Organised by Richard Rimbach Associates, 845 Ridge-avenue, Pittsburg 12, Pa., U.S.A.

Chicago Exposition of Power and Mechanical Engineering.—Mon., Nov. 14, to Fri., Nov. 18, at the Coliseum, Chicago, Ill., U.S.A., under the auspices of the American Society of Mechanical Engineers. Apply to the International Exposition Co., 480 Lexington-avenue, New York 17, U.S.A.

Building Exhibition, 26th.—Wed., Nov. 16, to Wed., Nov. 30, at Olympia, London, W.14. Apply to the Building Trades Exhibition, 4 Vernon-place, London, W.C.1. Tel. CHAncery 2223.

***Protection of Cable Sheathing Against Corrosion, Symposium.**—Fri., Nov. 18, at the Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. Organised by the Corrosion Group, Society of Chemical Industry, 56 Victoria-street, London, S.W.1. Tel. VICtoria 5215. Apply to Mr. S. C. Britton, Group hon. secretary, Tin Research Institute, Fraser-road, Greenford, Middlesex.

***Seattle Boat Show.**—Sat., Nov. 19, to Sun., Nov. 27, in Seattle Field Artillery Armoury. Apply to the general manager, 800 8th-avenue, Seattle 4, Wash., U.S.A.

Documentation of Applied Chemistry Congress.—Tues., Nov. 22, to Fri., Nov. 25, at the Institut Français du Royaume Uni, Queensberry-place, London, S.W.7. Apply to the International Congress on Documentation of Applied Chemistry, 56 Victoria-street, London, S.W.1. Tel. VICtoria 5974.

***Colombian Second International Industrial Fair.**—Fri., Nov. 25, to Sun., Dec. 11, at Bogota, Colombia. Apply to the Colombian Embassy, 3 Hans-crescent, London, S.W.1. Tel. KENsington 9177.

***Symposium on Corrosion.**—Mon., Nov. 28, to Fri., Dec. 2, at The University, Melbourne. Organised by the University of Melbourne, the Institution of Engineers, Royal Australian Chemical Institute, Australian Institute of Metals, Society of Chemical Industry, Australasian Institute of Mining and Metallurgy, and Australian Association for Corrosion Prevention. Apply to the honorary secretary, Symposium on Corrosion, Metallurgy Department, University of Melbourne, Carlton N.3, Victoria, Australia.

***British Nuclear Energy Conference, London Meeting.**—Wed., Nov. 30, at the Institution of Civil Engineers, Great George-street, London, S.W.1. Symposium of lectures. Attendance is restricted to members of the five institutions participating in the Conference. Information obtainable from the secretary of the Conference, Mr. A. McDonald, 1-7 Great George-street, London, S.W.1. See ENGINEERING, September 9, page 329.

***Hong Kong Products Exhibition (13th), Including International Machinery Display.**—Fri., Dec. 2, 1955, to Mon., Jan. 2, 1956, in Hong Kong. Apply to the Chinese Manufacturers' Union, 64-65 Connaught-road Central, Hong Kong.

***Smithfield Show and Agricultural Machinery Exhibition.**—Mon., Dec. 5, to Fri., Dec. 9, at Earl's Court, London, S.W.5. Apply to the exhibition manager, Smithfield Show Joint Committee, 148 Piccadilly, London, W.1. Tel. GROsvenor 4040.

Aluminium in Shipbuilding.—Wed. and Thurs., Dec. 7 and 8, at 10 Upper Belgrave-street, London, S.W.1. Joint symposium on "Use and Welding of Aluminium in Shipbuilding," organised by the Institute of Welding, the Institution of Naval Architects, the British Shipbuilding Research Association, the British Welding Research Association and the Aluminium Development Association. Apply to the secretary, Institute of Welding, 2 Buckingham Palace-gardens, London, S.W.1. Tel. SLOane 9851.

***National Boat Show, Second.**—Thurs., Dec. 29, 1955 to Tues., Jan. 10, 1956, at Olympia, London, W.14. Organised by the Ship and Boat Builders' National Federation, 205 Regent-street, London, W.1. Tel. REGent 1108.

***Kitale Air Show.**—Fri., Jan. 6, to Sun., Jan 8, 1956, at Kitale, Kenya. Further information obtainable from Captain N.E. Waugh, Harward, Maclachlan & Co., Ltd., P.O. Box 2159, Nairobi, Kenya.

Royal Agricultural and Food Exhibition.—Thurs., Jan. 12, to Thurs., Jan. 26, 1956, at the Ceylon Turf Club, Colombo. Agricultural and dairy machinery exhibits. Organised by the Exhibition Branch, Department of Commerce, P.O. Box 1507, Colombo, Ceylon.

***National Plant Maintenance and Engineering Show, Seventh.**—Mon., Jan. 23, to Thurs., Jan 26, 1956, at the Convention Hall, Philadelphia. Organised by Clapp and Poliak Inc., 341 Madison-avenue, New York 17, U.S.A.

***Stationery and Book Trades Fair, National.**—Mon., Feb. 6, to Fri., Feb. 10, 1956, at the Royal Horticultural Society's Old and New Halls, Vincent-square and Greycoat-street, London, S.W.1. Organised by the National Newsagent (Exhibitions) Ltd , 149 Fleet-street, London, E.C.4. Tel. CITy 2604.

***Stationery Trade Fair.**—Mon., Feb. 6, to Fri., Feb. 10, 1956, at Blackpool. Organised by the Stationers' Association of Great Britain and Ireland, 6 Wimpole-street, London, W.1. Tel. LANgham 9256.

***Hardware Trades Show.**—Mon., Feb. 20, to Fri., Feb. 24, 1956, at the Royal Horticultural Society's Old and New Halls, Vincent-square and Greycoat-street, London, S.W.1. Apply to the organising secretary, Hardware Trades Show, 74 Holland Park, London, W.11. Tel. PARk 7723.

***Business Efficiency Exhibition.**—Mon., Feb. 20, to Sat., Feb. 25, 1956, at Bingley Hall, Birmingham. Organised by the office Appliance and Business Equipment Trades Association, 11-13 Dowgate-hill, Cannon-street, London, E.C.4. Tel. CENtral 7771.

British Industries Fair.—Wed., Feb. 22, to Fri., Mar. 2, 1956 (including British Toy Fair), at Earl's Court, London, S.W.5. (Organised jointly with British Toy Manufacturers' Association.) Also Mon., April 23, to Fri., May 4, 1956, at Olympia, London, W.14, and at Castle Bromwich, Birmingham. Apply to British Industries Fair, Ltd., 9 Kingsway, London, W.C.2. Tel. COVent Garden 1461; or to general manager, B.I.F., 95 New-street, Birmingham, 2. Tel. Midland 5021.

***Brighton Smallwares Trade Fair.**—Mon., Feb. 27, to Fri., Mar 2, 1956, at the Metropole Hotel, Brighton. Organised by Trade and Technical Exhibitions, Ltd., 1 Dorset Buildings, Salisbury-square, London, E.C.4. Tel. FLEet 1555.

***Ideal Home Exhibition.**—Tues., Mar. 6, to Sat., Mar. 31, 1956, at Olympia, London, W.14. Organised by Associated Newspapers Ltd., New Carmelite House, London, E.C.4. Tel. FLEet 6000.

***Japan International Trade Fair.**—Sun., April 8, to Sun., April 22, 1956, at Osaka. Organised by the Japan International Trade Fair Commission, Honmachibashi, Higashi-Ku, Osaka, Japan.

***Factory Equipment Exhibition, Fourth.**—Mon., April 9, to Sat., April 14, 1956, at Earl's Court, London, S.W.5. Apply to Mr. J. E. Holdsworth, 4 Snow-hill, Holborn-viaduct, London, E.C.1. Tel. CENtral 0354.

***Mechanical Handling Exhibition, Fifth.**—Wed., May 9, to Sat., May 19, 1956, at Earl's Court, London, S.W.5. Organised by *Mechanical Handling*, Dorset House, Stamford-street, London, S.E.1. Tel. WATerloo 3333.

***Physical Society's Exhibition of Scientific Instruments and Apparatus.**—Mon., May 14, to Thurs., May 17, 1956, at the Royal Horticultural Society's Old and New Halls, Vincent-square and Greycoat-street, London, S.W.1. Organised by the Physical Society, 1 Lowther-gardens, Prince Consort-road, London, S.W.7. Tel. KENsington 0048.

***Production Exhibition.**—Wed., May 23, to Thurs., May 31, 1956, at Olympia, London, W.14. Organised by Andry Montgomery Ltd., 11 Avenue Chambers, 4 Vernon-place, London, W.C.1. Tel. CHAncery 2223.

***Machine Tool Exhibition, International.**—Fri., June 22, to Fri., July 6, 1956, at Olympia, London, W.14. Organised by the Machine Tool Trades Association, Victoria House, Southampton-row, London, W.C.1. Tel. HOLborn 4667.

***Australian World's Fair.**—Thurs., July 26, to Sat., Aug. 4, 1956, at Sydney. Apply to the managing director, Australian World's Fair, 234 Clarence-street, Sydney, N.S.W., Australia.

***Commercial Motor Transport Exhibition, International.**—Fri., Sept. 21, to Sat., Sep. 29, 1956, at Earl's Court, London, S.W.5. Organised by the Society of Motor Manufacturers and Traders, Ltd., 148 Piccadilly, London, W.1. Tel. GROsvenor 4040.

***Knitting Machinery and Accessories Exhibition.**—Wed., Oct. 17 to Sat., Oct. 27, 1956, at Leicester. Organised by Textile Recorder Exhibitions Ltd., Old Colony House, South King-street, Manchester 2. Tel. Blackfriars 7234.

***Motor Show (41st International Motor Exhibition).**—Wed., Oct. 17, to Sat., Oct. 27, 1956, at Earl's Court, London, S.W.5. Organised by the Society of Motor Manufacturers and Traders, Ltd., 148 Piccadilly, London, W.1. Tel. GROsvenor 4040.

***Cycle and Motor Cycle Show, 31st International.**—Sat., Nov. 10, to Sat., Nov. 17, 1956, at Earl's Court, London, S.W.5. Organised by the British Cycle and Motor Cycle Manufacturers' and Traders' Union, Ltd., The Towers, Warwick-road, Coventry. Tel. Coventry 62511.

***Public Works and Municipal Services Congress and Exhibition.**—Mon., Nov. 12, to Sat., Nov. 17, 1956, at Olympia, London, W.14. Organised by the Municipal Agency Ltd., 70 Victoria-street, London, S.W.1. Tel. VICtoria 9132.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

LONDON
"Applications of Carbon in Electrical Engineering," by A. E. Feaver. West London Branch. Windsor Castle Hotel, 134 King-street, Hammersmith, W.6. Tues., Oct. 4, 7.30 p.m.
"Modernisation and Re-equipment of British Railways," by W. N. Glossop. North London Branch. 677 Green-lanes, Harringay, N.4. Wed., Oct. 5, 7.45 p.m.
CARDIFF
"Theatrical Lighting," by C. W. Timms. South Wales Branch. Angel Hotel, Westgate-street, Cardiff. Tues., Oct. 4, 7.30 p.m.
CROYDON
"A Supply Engineer's Visit to Italy," by A. Tonge. South London Branch. Half Moon Hotel, Broad Green, Croydon. Thurs., Oct. 6, 8 p.m.
ELTHAM
"Heavy Switchgear," by J. H. Marlow. South-East London Branch. Congregational Church, Eltham. Tues., Oct. 4, 8 p.m.
ILFORD
Film Evening. North-East London Branch. Angel Hotel, Ilford. Mon., Oct. 3, 8 p.m.
LEEDS
"Photo-Electric Devices in Industry," by A. Hickman. Leeds Branch. Great Northern Hotel, Leeds. Mon., Oct. 3, 7.30 p.m.
LIVERPOOL
"Electric Fire-Alarm Systems," by C. R. Mansell. Liverpool Branch. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool. Fri., Oct. 7, 7.30 p.m.
MANCHESTER
Debate on "Contracting versus Maintenance." Manchester Branch. Engineers' Club, Albert-square, Manchester. Wed., Oct. 5, 7.30 p.m.

British Institution of Radio Engineers

LIVERPOOL
"Stereophonic Sound," by R. A. Bull. Merseyside Section. Liverpool Chamber of Commerce, 1 Old Hall-street, Liverpool, 3. Wed., Oct. 5, 7 p.m.
MANCHESTER
"Colour Television," by Dr. G. N. Patchett. North Western Section. College of Technology, Sackville-street, Manchester. Thurs., Oct. 6, 6.30 p.m.

Building Centre

LONDON
Film Evening. Wed., Oct. 5, 12.45 p.m.

Chemical Society

BRISTOL
"Impact of Nuclear Energy on Industry," by Dr. J. M. Fletcher. Bristol Branch. Chemistry Department, The University, Bristol. Thurs., Oct. 6, 7 p.m.
MANCHESTER
"Inorganic Metallic Aspects of Atomic Energy," by L. Rotherham. Manchester Branch. The University, Manchester. Wed., Oct. 5, 6.30 p.m.

Illuminating Engineering Society

LONDON
Presidential Address by A. G. Higgins. Royal Institution, 21 Albemarle-street, W.1. Tues., Oct. 11, 6 p.m.
CARDIFF
"Lighting for Sport," by M. W. Peirce. Cardiff Centre. Offices of the South Wales Electricity Board, The Hayes, Cardiff. Thurs., Oct. 6, 5.45 p.m.
EDINBURGH
"Shop and Store Lighting." by R. L. C. Tate. Edinburgh Centre. Y.M.C.A., 14 St. Andrews-street, Edinburgh, 2. Wed., Oct. 5, 6.15 p.m.
GLASGOW
"The Architect and the Society's New Code," by A. Buchanan Campbell. Glasgow Centre. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Thurs., Oct. 6, 6.30 p.m.
NEWCASTLE-UPON-TYNE
Chairman's Address, by J. N. K. Rankin. Newcastle Centre. King's College, College-road, Newcastle-upon-Tyne. Wed., Oct. 5, 6.15 p.m.
NOTTINGHAM
Chairman's Address, by P. A. Moore. Nottingham Centre. Offices of the East Midlands Electricity Board, Smithy-row, Nottingham. Thurs., Oct. 6, 6 p.m.

Incorporated Plant Engineers

LONDON
"Air Pollution Problems and Their Cure," by J. B. M. Mason. London Branch. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Tues., Oct. 4, 7 p.m.
BOURNEMOUTH
"Modern Trends in Heating and Ventilation," by Colonel A. Concannon. Southampton Branch. Grand Hotel, Bournemouth. Wed., Oct. 5, 7.30 p.m.
EDINBURGH
Discussion on "Feedwater Treatment." Edinburgh Branch. 25 Charlotte-square, Edinburgh. Tues., Oct. 4, 7 p.m.
LIVERPOOL
"Statutory Requirements in Connection with Boilers and Pressure Vessels," by G. A. Anderson. Merseyside and North Wales Branch. Liverpool Royal Institution, Colquitt-street, Liverpool. Thurs., Oct. 6, 7.15 p.m.
PETERBOROUGH
"Gas Turbines in Industry," by J. R. Needham. Peterborough Branch. Campbell Hotel, Bridge-street, Peterborough. Thurs., Oct. 6, 7.30 p.m.

Institute of Fuel

LONDON
"The Effect of Coal Quality on the Efficiency of a Shell Boiler Equipped with a Travelling-Grate Stoker," by E. J. MacDonald and M. V. Murray. Institution of Civil Engineers, Great George-street, S.W.1. Wed., Oct. 5, 5.30 p.m.
CARDIFF
"Implications of the Rivers (Prevention of Pollution) Act, 1951," by A. H. Williams. South Wales Section. South Wales Institute of Engineers, Park-place, Cardiff. Fri., Oct. 7, 6 p.m.
SHEFFIELD
Chairman's Address, by H. E. Pearsall. Yorkshire Section. Royal Victoria Hotel, Sheffield. Wed., Oct. 5, 2.30 p.m.
STOKE-ON-TRENT
"National Fuel Resources in the Light of National Fuel Requirements," by Dr. G. E. Foxwell. Midland Section. Offices of the Midlands Electricity Board, Kingsway, Stoke-on-Trent. Tues., Oct. 4, 7 p.m.

Institute of Marine Engineers

LONDON
Presidential Address on "The Century in Which We Live," by A. J. Silley. Tues., Oct. 4, 5.30 p.m.

Institute of Road Transport Engineers

BRISTOL
"Fire Precautions in the Oil Industry," by D. W. Thomas. Western Centre. Royal Hotel, Bristol. Wed., Oct. 5, 7.30 p.m.
GLASGOW
"Gas Turbine Development for Road Transport," by P. A. Phillips. Scottish Centre. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Mon., Oct. 3, 7.30 p.m.
IPSWICH
"Maintaining a Mixed Dispersed Fleet," by W. L. Gage. Eastern Centre. Golf Hotel, Ipswich. Tues., Oct. 4, 7 p.m.
NOTTINGHAM
"Clutch and Brake Linings," by L. P. Godfrey. East Midlands Centre. Mechanics' Institute, Nottingham. Wed., Oct. 5, 7.30 p.m.

Institution of Civil Engineers

LONDON
"Selected Aspects of the Geometric Design of Airports," by John H. Jones. Tues., Oct. 4, 5.30 p.m.
LIVERPOOL
"The Architectural and Engineering Aspects of Building Design," by E. Shepley and W. A. Gibbon. North Western Association. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool. Wed., Oct. 5, 6.30 p.m.
MANCHESTER
"The Architectural and Engineering Aspects of Building Design," by E. Shepley and W. A. Gibbon. North Western Association. College of Technology, Manchester. Tues., Oct. 4, 6.45 p.m.

Institution of Electrical Engineers

LONDON
Presidential Address by Sir George H. Nelson. Thurs., Oct. 6, 5.30 p.m.
BIRMINGHAM
Chairman's Address by Lieut.-Colonel H. S. Davidson. South Midland Centre. Annual General Meeting and Conversazione. Grand Hotel, Birmingham. Mon., Oct. 3, 6 p.m.
LEEDS
Chairman's Address by F. Barrell. North Midland Centre. Offices of the Yorkshire Electricity Division, 1 Whitehall-road, Leeds. Tues., Oct. 4, 6.30 p.m.
LIVERPOOL
Chairman's Address on "Electrical Discharges in Gases," by Professor J. M. Meek. Mersey and North Wales Centre. Liverpool Royal Institution, Colquitt-street, Liverpool. Mon., Oct. 3, 6.30 p.m.
LOUGHBOROUGH
Informal Conversazione and Reunion. East Midland Centre. Loughborough College, Loughborough. Tues., Oct. 4, 6.30 p.m.
MANCHESTER
Chairman's Address on "Ethical Aspects of Electrical Engineering Progression," by G. V. Sadler. North Western Centre. Engineers' Club, Albert-square, Manchester. Tues., Oct. 4, 6.30 p.m.
PORTSMOUTH
Chairman's Address by L. H. Fuller. Southern Centre. College of Technology Extension, Anglesea-road, Portsmouth. Wed., Oct. 5, 6.30 p.m.
WEYMOUTH
"High-Speed Photography: Methods and Applications," (illustrated), by W. D. Chesterman. Southern Centre. South Dorset Technical College, Weymouth. Fri., Oct. 7, 6.30 p.m.

Institution of Engineers-in-Charge

LONDON
Presidential Address by R. L. Quertier. St. Bride Institute, Bride-lane, Fleet-street, E.C.4. Wed., Oct. 12, 6.30 p.m.

Institution of Engineers and Shipbuilders in Scotland

GLASGOW
Presidential Address by Professor A. M. Robb. Tues., Oct. 4, 7.30 p.m.

Institution of Heating and Ventilating Engineers

BIRMINGHAM
"Some Aspects of Industrial Air Conditioning," by J. Carter, Birmingham Branch. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham, 2. Thurs., Oct. 6, 6.30 p.m.
LEICESTER
"Snags in Thermostatic Control," by Dr. F. M. H. Taylor. East Midlands Branch. College of Technology, Leicester. Wed., Oct. 5, 6.45 p.m.

Institution of Highway Engineers

LONDON
"Aerial Surveys and the Practical Application of Results Therefrom," by B. F. J. Bradbeer and others. Institution of Structural Engineers, 11 Upper Belgrave-street, S.W.1. Fri., Oct. 7, 5.30 p.m.

Institution of Locomotive Engineers

LONDON
"The British Railways Mechanical Iron Foundry, Horwich," by S. A. S. Smith. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Wed., Oct. 5, 5.30 p.m.

Institution of Mechanical Engineers

MANCHESTER
"Bending Stress in Spur Gear Teeth: Proposed New Design Factors Based on a Photoelastic Investigation," by M. A. Jacobson. North Western Branch. Engineers' Club, Albert-square, Manchester. Thurs., Oct. 6, 6.45 p.m.
MIDDLESBROUGH
"A Review of Freight Aircraft," by B. P. Laight. North Eastern Branch. Cleveland Scientific and Technical Institution, Corporation-road, Middlesbrough. Tues., Oct. 4, 6.30 p.m.
NEWCASTLE-UPON-TYNE
"A Review of Freight Aircraft," by B. P. Laight. North Eastern Branch. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., Oct. 3, 6 p.m.

Institution of Production Engineers

CHELMSFORD
"Training of Production Managers and Production Engineers," by G. S. Bosworth. South Essex Section. Mid-Essex Technical College, Chelmsford. Wed., Oct. 5, 7.30 p.m.
LEEDS
"Valid Incentives," by E. C. Gordon England. Regional Meeting. Chemistry Lecture Theatre, The University, Leeds 2. Mon., Oct. 3, 7 p.m.
PETERBOROUGH
"A Lecture on Lecturing," by R. Parmenter. Peterborough Section. Campbell Hotel, Bridge-street, Peterborough. Tues., Oct. 4, 7.30 p.m.
READING
"Production Control as Applied to Small and Medium-Size Companies," by F. T. Hunter. Reading Section. Great Western Hotel, Reading. Thurs., Oct. 6, 7.30 p.m.

Institution of Structural Engineers

LONDON
"Presidential Address by Stanley Vaughan. Thurs., Oct. 6, 6 p.m.
BRISTOL
Chairman's Address by N. G. T. Ball. Western Counties Branch. The University, Bristol. Fri., Oct. 7, 6 p.m.
MIDDLESBROUGH
"Relationship Between Structural Engineering and Civil Engineering," by E. A. Parsons. Northern Counties Branch. Cleveland Scientific and Technical Institution, Middlesbrough. Tues., Oct. 4, 6.30 p.m.

Institution of Works Managers

LONDON
Annual General Meeting and Film Evening. London Branch. Waldorf Hotel, Aldwych, W.C.2. Tues., Oct. 4, 7 p.m.
LEICESTER
Discussion on "Are Lawyers Useful to Business?" to be opened by Sir Geoffrey Barnett. Followed by Branch's Annual Dinner. Leicester Branch. Grand Hotel, Leicester. Tues., Oct. 4, 7 p.m.

Junior Institution of Engineers

LONDON
Film: "The Raising of H.M. Submarine Truculent," to be introduced by Lieut.-Commander L. Hackman, R.N.R. Fri., Oct. 7, 7 p.m.

King's College London

LONDON
"The University Scene in Australia," by Professor A. H. Willis. Fri., Oct. 7, 5.30 p.m.

Royal Aeronautical Society

LONDON
"The Growth of Aeronautical Research in Canada during the Post-War Decade," by Dr. J. J. Green. The Eleventh British Commonwealth and Empire Lecture. The Royal Institution, 21 Albemarle-street, London, W.1. Thurs., Oct. 6, 6 p.m.

Royal Statistical Society

LONDON
"Quality Control in the Paper Industry," by I. F. Hendry. London Industrial Applications Group. Lighting Service Bureau, 2 Savoy-hill, W.C.2. Fri., Oct. 7, 6 p.m.
BIRMINGHAM
"Uses of Factor Analysis in Industrial Physics," by G. W. Scott Blair. Birmingham Industrial Applications Group. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham, 2. Wed., Oct. 5, 6.45 p.m.
CARDIFF
"Opinion Survey," by Dr. Mark Abrams. South Wales Industrial Applications Group. University College, Cathays Park, Cardiff. Thurs., Oct. 6, 7 p.m.

Sheffield Metallurgical Association

SHEFFIELD
"Some Aspects of Materials for Aero Engines," by H. E. Gresham. B.I.S.R.A. Laboratories, Hoyle-street, Sheffield, 3. Tues., Oct. 4, 7 p.m.

Society of Engineers

LONDON
"Electronics in Industry," by J. Cosier. Geological Society's Apartments, Burlington House, Piccadilly, W.1. Mon., Oct. 3, 5.30 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021).
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineers-in-Charge, 100 Earlsfield-road, London, S.W.18. (BATtersea 1394.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Highway Engineers, 47 Victoria-street, London, S.W.1. (ABBey 3891.)
Institution of Locomotive Engineers, 28 Victoria-street, London, S.W.1. (ABBey 6672.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Institution of Works Managers, 67–68 Chandos-place, London, W.C.2. (TEMple Bar 8324.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
King's College, Strand, London, W.C.2. (TEMple Bar 5454.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Statistical Society, 21 Bentinck-street, London, W.1. (WELbeck 7638.)
Sheffield Metallurgical Association, 15 Crescent-road, Sheffield, 7. (Sheffield 53674.)
Society of Engineers, 17 Victoria-street, London, S.W.1. (ABBey 7244.)

THE HUMAN ELEMENT

Motions at Conservative Party Conference will support Government's encouragement of profit sharing and co-partnership; unrest growing in French industry; a milder approach to conciliation in London Transport dispute; miners forget country's needs in expressing their own; proscription of Stevedores' Union still a source of friction in the docks; and a call for better communications between management and shop floor.

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Profit Sharing and Co-Partnership

Neither of the large political parties does its best or most serious thinking at their respective annual conferences, but the flow of resolutions which are put up shows the general drift of party thinking in the constituencies and the nature of the pressure they are likely to put upon their central executive in the coming year. Two items of interest for these notes appear on the Conservative programme for Bournemouth next month. They are significant for the future of management-labour relations, and concern profit-sharing and industrial relations.

A motion is to be debated congratulating the Government on its encouraging profit-sharing and co-partnership in industry and suggesting that progress should be speeded up. To judge from the other resolutions on this subject which were unsuccessful candidates for debate, speeding progress might mean closer co-operation with the T.U.C., taxation relief for profit-sharing schemes and extension of co-partnership to the nationalised industries. There would be no harm in having one (or both) of the big political parties in favour of the gradual extension of profit-sharing, provided it does not delude people into thinking that here is the panacea for all industrial complaints or that progress can be quicker than both sides of industry in each particular case are prepared to permit.

There is a widely drafted motion on industrial relations calling for more effective co-operation between management and labour to avoid recourse to strikes. There are 20 unsuccessful resolutions supporting this one at the conference so it is likely to provide one of the bigger debates of the week. Most good will come of it if those who have practical experience of industry can make themselves heard above the hubbub of well-intentioned but ineffective discussion on economic and political generalisations.

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From Bad to Worse

Unrest is growing in French industry; after a week of lightning strikes by bus, underground and suburban railway workers in Paris, the railway engine-drivers' union called a 24-hour strike last week which was followed by an immediate and complete standstill throughout the country. Meanwhile the disputes over wages in the metals, engineering and shipbuilding industries continued to lead to strikes and lock-outs marked by rioting and much bitterness on both sides. The wave of violence, which began at Nantes about a month ago, spread to a steel rolling mill and a shipyard in Le Havre, where members of the management were imprisoned and administrative offices sacked. At Nantes a one-day general strike was held in sympathy with engineering workers.

The strikes are becoming more and more political. The railwaymen's strike was led by the C.G.T. (Communist-led), and opposed by the minority unions (Socialist and Christian). The C.G.T.'s allegations that workers' purchasing power is on the decline and that wage increases could easily be paid out of "scandalous capitalist profits" were refuted by the Prime Minister, M. Edgar Faure, in a personal broadcast appeal to French workers. Yet there is little doubt that the strikers, and the C.G.T. also, are receiving wider support than at any time during the past eight years. So far, offers of wage increases have fallen much more below the unions' demands than is usual in Britain, as have the recommendations of the official mediator (an innovation in France).

The conclusion that France is on the way to a major industrial upheaval is hard to avoid; the cost of the Indo-China war and the current military requirements in North Africa have for years proved too heavy a burden. Opposition to the Government by taxpayers—particularly by retailers and very small firms—is gathering support, and sooner or later organised labour and the self-employed will join hands and may well upset the present political balance of power.

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Bus Dispute for Conciliation

The unending struggle to keep London's bus system fully manned, but solvent, goes on. The basic problem of providing a large and highly organised service for some eight million people living in a congested conurbation, at a price which they are prepared to pay, is continually in conflict with the fact that the buses have to be worked by labour drawn from the largest and most expensive market (because most prosperous) in the country. Complete disagreement has been reached between the London Transport Executive and the Transport and General Workers' Union on the latest wage demand, for an extra 25*s*. a week.

Following a long and unsuccessful meeting last week between the two parties, it was agreed that the Minister of Labour should be asked to set up a Board of Conciliation under the Conciliation Act of 1896. The meeting actually considered two issues. The other one was a sick pay scheme for which the union is pressing and which would give its members the same treatment as supervisory grades. The L.T.E. has agreed to look into this matter.

A conciliation board has not been used since a railway dispute in 1949. It is considered a more mild form of compromise than arbitration. The negotiations are thus to some extent still in a state of flux and tempers remain commendably cool.

But in reconciling high wages with low fares the London Transport Executive have always had a somewhat easier task perhaps than British Railways. Firstly, its customers have in general no alternative but to continue to use its services whatever the cost, and secondly, unlike the railway traveller, whose fares rise in increments of several shillings and whose sales resistance stiffens accordingly, the London passenger, on learning that his shilling fare has gone up by, say, a penny, will pay up with scarcely a murmur—though probably without a smile. Nevertheless the L.T.E. has a hard formula to apply, namely, how to pay more to its operatives and at the same time satisfy a public which wants cheap transport.

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Miners' "Charter"

There is nothing new in the "charter" which the executives of the National Union of Mineworkers are going to put to the National Coal Board in the near future. It is little more, in one sense, than a cleaning-up operation after the annual summer conference—a moulding of the resolutions into a coherent plan of action for the new year. From the public's point of view, it looks like a gesture in rather bad taste. The miners are seen to be arguing about working less when the crying need is for them to work harder.

This "charter" has four points. These are: reduction in hours worked, an increase in paid holidays from two to three weeks a year, the payment of wages during sickness, and consolidation of the "bonus" shift. The present bonus position is that if a miner works five shifts he is paid as if he had worked six but if he misses a shift he is paid only for what he has worked. There is nothing in the union's suggestion that this arrangement should be abolished and the bonus spread over the five shifts, or for that matter, in the other three points, which the N.C.B. or the public would oppose on principle. The difficulty is that the miners are continually in the position that they get before they give. In the case of the extra week's holiday for example, the immediate effect is sure to be a loss of 4 million tons of coal. From past experience there is no likelihood that the miners will make this up.

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Frayed Tempers in the Docks

How bad the relations between the two dockers' unions, and for that matter between dockers and the Dock Labour Board, have become was brought out last week in Liverpool by the one-day token strike staged by the National Amalgamated Stevedores and Dockers Union over the dismissal of two of their members. The two men were alleged to have called two members of the Transport and General Workers Union "scabs" and were sacked by the local Dock Labour Board for improper conduct. An appeals tribunal promptly reinstated them. This incident, in itself so trivial, could hardly have become a major issue elsewhere; in this case it was sufficient to bring out 7,000 of the port's 16,000 dockers.

The upshot of the affair—according to Mr. Bill Johnson, area officer of the unrecognised N.A.S.D.U.—was a meeting in Hull last Saturday of delegates from Liverpool, Birkenhead, Manchester and Hull "to discuss the position of our membership in the North, and future policy regarding working conditions, representation and recognition." The union is clearly determined to fight hard to secure its aims and only the wisest leadership on the part of the D.L.B. and the T.G.W.U. can prevent the conflict from spreading.

Peace in the docks, so often disturbed since the inception of the Dock Labour Scheme after the war, will not be easily established until the scheme itself has been revised to take into account the many shortcomings brought out by successive strikes. The special committee which was appointed by Sir Walter Monckton last August to inquire into the Dock Labour Scheme have therefore a most urgent task before them if the country is to avoid another crippling strike.

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Official Hints on Management

A plea for better co-operation between workers and managements was made last week by Mr. H. Watkinson, Parliamentary Secretary to the Ministry of Labour. Having warned us that full employment depended not so much on Government policy as on the nation's ability to earn through exports "sufficient currency to buy the raw materials for our factories," he went on to underline the importance of effective communications between management and the shop floor. The promotion of mutual understanding at all levels was one of industry's most urgent tasks. He pointed out that the real danger to full employment did not lie in the installation of labour-saving machines, in automatic controls or in workers producing too much, although workers' fears, based on past experience, were realistic enough and should not be brushed aside. In his view the real danger lies "in the refusal to change—in being left behind in the struggle for a share of the markets of the world or being priced out of them." It is the task of management to put this across and to make sure that what is happening to the firm and the broad basis of management policy are widely understood.

Such an official view on industrial management is refreshing, and in line with the thoughts expressed in recent months by several industrial leaders. Basically, it is that the country cannot become economically viable without the co-ordinated efforts of all engaged in production, and that this can only result from wide understanding of the nation's and of industry's tasks and problems.